KANNUR UNIVERSITY

(Abstract)

New Generation Courses in Affiliated Colleges-- M.Sc. Plant Science with Bioinformatics Programme under Credit Based Semester System at Payyannur College-- w.e.f.2021-22 admission--Scheme, Syllabus and Model Question papers --implemented orders Issued.

ACADEMIC C SECTION

Acad/C2/6474/NGC/2021 Dated: 16.08.2021

Read:-1. The Minutes of the meeting of the Syndicate held on 17.11.2020 vide item No. 2020.550

2. GO (Ms) No. 15/2021/HEDN dated 25/02/2021

3. U.O No Acad. A3/389/NEW GENERATION COURSES/2020-21 dated 15/03/2021

4. U.O Acad/C2/6474/NGC/2021 dated 27.03.2021

5. U.O Acad/C1/11460/2013 dated 12.03.2014

6. The Syllabus of M.Sc.Plant Science with Bioinformatics programme, submitted by the Convener, Curriculum Syllabus Monitoring Committee on 31.07.2021

ORDER

1. As per paper read (1) above, the meeting of the Syndicate, held on 17.11.2020 resolved vide item No. 2020.550 to start the newly sanctioned programmes in Govt./ Aided Colleges/ University Departments from the academic year 2020-21 and to entrust the Curriculum Syllabus Monitoring Committee to finalize the Syllabus of the new programmes, constituting an Expert Committee, comprising with the former Chairpersons of Board of Studies [UG/PG], Heads of the Departments of Colleges/ University Departments concerned and an External Expert.
2. As per paper read (2) above, the Govt. granted Administrative sanction for starting the M.Sc.Plant Science with Bioinformatics programme at Payyanur College, Payyanur, Edat, Kannur (Dist) for the academic year 2020-21.
3. Accordingly, vide paper (3)above,Provisional Affiliation was granted to the M.Sc. Plant Science with Bioinformatics programme at Payyanur College, Payyanur for the academic year 2020-21.
4. Subsequently, an Expert committee was constituted as per the paper read (4)above, to prepare the Draft Syllabus of the M.Sc. Plant Science with Bioinformatics programme and to follow the existing Regulations of the PG programmes in affiliated Colleges under CBSS, implemented as per paper read (5), w.e.f 2014 admission.
5. Accordingly, the Scheme, Syllabus and Model Question Papers of the M.Sc. Plant Science with Bioinformatics programme, prepared by the Expert Committee was submitted by the Convener, Curriculum Syllabus Monitoring Committee, as per the paper read (6), for implementation w.e.f 2021 admission at Payyanur College, Payyanur.
6. The Vice-Chancellor, after considering the matter in detail and in exercise of the powers of the Academic Council conferred under Section 11(1) Chapter III of Kannur University Act 1996, accorded sanction to implement the Scheme, Syllabus & Model Question Papers of the M.Sc. Plant Science with Bioinformatics programme, at Payyanur College, Payyanur, Edat, Kannur,w.e.f. 2021 admission.

7. The Scheme, Syllabus & Model Question Papers of the M.Sc. Plant Science with Bioinformatics programme (CBSS) are uploaded in the University website (www.kannuruniv.ac.in).

Orders are issued accordingly.

sd/-
BALACHANDRAN V K
DEPUTY REGISTRAR (ACAD)
For REGISTRAR

To: The Principal
Payyanur College

Copy To: 1. The Examiantion Branch (through PA to CE)
2. PS to VC/PA to PVC/PA to Registrar
3. DR/ARI Academic
4. The Computer Programmer (for upla
3. SF/DF/FC

Forwarded / By Order

SECTION OFFICER

KANNUR UNIVERSITY
POST OFFICE STATION P.O.
KANNUR
THAVAKKARA

KANNUR UNIVERSITY

Syllabus for

M. Sc. PLANT SCIENCE with BIOINFORMATICS

Credit Based Semester System
(KUCBSS-PG-2014)

2021 admission onwards

Kannur University
Thavakkara, Civil Station P.O.
Kannur District. Kerala 670 002, India.

Preface

The higher education sector in Kerala is now under a comprehensive overhaul, modernization and up gradation with the unwavering support of the Government of Kerala. Among the many modern interdisciplinary Post Graduate courses sanctioned to the Kannur University during the Academic Year 2020-21, two programmes are in Plant Science stream: M.Sc. Plant Science with Ethnobotay at Kannur University Mannanthavady Campus, and M.Sc. Plant Science with Bioinformatis at Payyanur College, Payyanur. The new programme, M.Sc. Plant Science with Bioinformatics has added employability and scope for higher studies due to the inclusion of two core courses on Bioinformatics, along with all the conventional botany courses. The syllabus of the programme bestow the students with an opportunity for training in advanced areas of biosciences like bioinformatics, genomics and molecular biology with a sound theoretical back ground. The syllabus is constituted with twelve core courses, two elective courses (to be selected from the seven courses provided), and six practical courses including general *viva voce* and project evaluation. The programme also offers the students an exposure on interdisciplinary areas of conventional areas of botany studies. Those graduated in the programme are expected to be well suited for botanical research institutes, forest research institutions, and other institutions requiring specialization in proteomics and genomics.

Northern Kerala, where the jurisdiction of Kannur University located, is well known for its laterite hill ecosystems with very diverse and characteristic flora showing seasonal variations. The lack of adequate research institutes and higher education centres in this area leads to a failure in creating awareness on such 'micro hotspots' of biodiversity. Establishment of facilities with post graduate studies and research in this area is hopeful in conservation of these ecosystems and sustainable utilization of their biodiversity. Such a programme with a perfect blend of conventional and modern streams in science is, of course, a promise in the imminent history of the university. The members of the committee constituted for drafting the syllabus of the programme, would like to acknowledge the help, immense support and advices rendered by various experts and teachers, during the preparation of the draft.

Members of the Expert Committee
MSc Plant Science with Bioinformatics

KANNUR UNIVERSITY

M.Sc. PLANT SCIENCE WITH BIOINFORMATICS

(Effective from **2021 admission** onwards)

CREDIT DISTRIBUTION CHART OF COURSES IN THE M.Sc. PROGRAMME

Semester No.	Course No.	Title of the Course	Credits
I	PSB1C01	Cell Biology and Molecular Genetics	4
	PSB1C02	Microbiology, Mycology and Plant Pathology	4
	PSB1C03	Phycology, Bryology and Pteridology	4
	PSB1C04	Gymnosperms, Angiosperm Anatomy and Embryology	4
II	PSB2C05	Environmental Science, Forest Botany and Phytogeography	4
	PSB2C06	Genetics, Plant Breeding and Biostatistics	4
	PSB2C07	Evolution, Microtechnique and Instrumentation	4
	PSB2C08	Microbial and Plant Biotechnology	4
	PSB2P01	**Practical I**: Cell Biology, Microbiology, Mycology, Plant Pathology, Phycology, Bryology, Pteridology, Gymnosperm Botany, Environmental Science and Forest Botany	4
	PSB2P02	**Practical II**: Angiosperm Anatomy, Embryology, Evolution, Genetics, Biostatistics, Plant Breeding, Bioinstrumentation, Microbial and Plant Biotechnology	4
III	PSB3C09	Plant Physiology and Biochemistry	4
	PSB3C10	Angiosperm Morphology and Systematics	4
	PSB3C11	Basic Bioinformatics	4
	PSB3C12	Structural Bioinformatics	4
IV	PSB4E01	Elective Course 1	4
	PSB4E02	Elective Course 2	4
	PSB4P03	**Practical III** : Angiosperm Morphology, Systematics, Plant Physiology and Biochemistry	4
	PSB4P04	**Practical IV**: Basic Bioinformatics, Structural Bioinformatics and Elective 1 and 2	4
	PSB4P05	Project/Dissertation	6
	PSB4P06	General/Course Viva Voce	2
		Total	80

ELIGIBILITY

Qualification: Candidates with the following B.Sc. degrees are eligible for admission to M.Sc. Plant Science with Bioinformatics Programme:

B.Sc. Degree of Kannur University with Botany (Core) or Plant Science (Core) or an equivalent degree of any other University recognized by this University.

Age and other criteria: As per the Kannur University PG Regulations on Admission

DURATION OF THE PROGRAMME

The duration for completion of the Programme is four semesters. The duration of each semester shall be five months inclusive of examinations. There shall be at least 90 instructional days and a minimum of 450 instructional hours in a semester. I and III semesters shall be from June to October and II and IV semesters shall be from November to March.

ATTENDANCE

The students admitted in the P.G. programme shall be required to attend at least 75% percent of the total number of classes (theory/practical) held during each semester. The students having less than prescribed percentage of attendance shall not be allowed to appear for the University examination. Attendance of each course will be evaluated (internally) as below:

Attendance %	% Marks for attendance
Above 90	100
85 to 89	80
80 to 84	60
76 to 79	40
75	20

END SEMESTER EVALUATION (ESE):

The End Semester Examination in theory courses is to be conducted by the University with question papers set by external experts. The evaluation of the answer scripts shall be done by examiners based on a well-defined scheme of valuation. End Semester Evaluation in Practical courses shall be conducted and evaluated by two examiners - one internal and one external.

EXAMINATION

There shall be University examination at the end of each semester. Practical examinations (External) shall be conducted by the University at the end of even semesters. Project evaluation and External Viva –Voce shall be conducted at the end of the programme only. Project evaluation and *Viva-voce* shall be conducted on *separate days* by two external examiners.

Evaluation and Grading

The evaluation scheme for each course (including projects) shall contain two parts; (a)

Continuous Assessment (CA) and (b) End Semester Evaluation (ESE). **20%** marks shall be given to CA and the remaining **80 %** to ESE. The ratio of marks between internal and external is 1:4 excluding viva-voce. Both internal and external evaluation shall be carried out using marks with corresponding grades and grade points in **7 point indirect relative grading system.**

Continuous Assessment (CA)

This assessment shall be based on predetermined transparent system involving periodic written tests, assignments, seminars and attendance in respect of theory courses and based on tests, lab skill, records/viva and attendance in respect of practical courses. The percentage of marks assigned to various components for internal evaluation is as follows.

Theory

Component	% of internal marks
Two test papers	40
Assignments/ Book review/ Debates	20
Seminar/ Presentation of case study	20
Attendance	20

Practical

Component	% of internal marks
Test Papers	40
Lab skill	20
Records/viva	20
Attendance	20

To ensure transparency of the evaluation process, the internal assessment marks awarded to the students in each course in a semester shall be published on the notice board at least one week before the commencement of external examination. There shall not be any chance for improvement for internal marks. The course teacher shall maintain the academic record of each student registered for the course, which shall be forwarded to the University, through the college Principal, after endorsed by the HoD.

Tests

For each course there shall be at least two class tests during a semester. The probable dates of the tests shall be announced at the beginning of each semester. Marks should be displayed on the notice board. Valued answer scripts shall be made available to the

students for perusal within 10 working days from the date of the tests.

Assignments

Each student shall be required to do 2 assignments/Book review for each course. Assignments/Book review after valuation must be returned to the students. The teacher shall define the expected quality of the above in terms of structure, content, presentation etc. and inform the same to the students. Punctuality in submission is to be considered.

Seminar

Every student shall deliver one seminar as an internal component for every course and must be evaluated by the respective course teacher in terms of structure, content, presentation and interaction. The soft and hard copies of the seminar report are to be submitted to the teacher in charge.

Elective Courses

Two elective courses are to be selected from the seven elective courses, during the fourth semester. The model question for the theory course will be in the same pattern as that of other core theory papers. The questions for the Practical IV, from this part (Elective Courses) will be decided by the Board of Examiners from year to year, depending on the elective courses selected. The list of elective courses are given below.

Course Code	Title of the elective course	Hours per week		Credits
		Theory	Practical	
PSB4E01	Applied Botany	99	36	4
PSB4E02	Horticulture and Mushroom Cultivation	90	45	4
PSB4E03	Bioethics, Biosafety and Intellectual Property Rights	99	36	4
PSB4E04	Plant Tissue Culture	81	54	4
PSB4E05	Phytoresources, Phytochemistry and Pharmacognosy	90	45	4
PSB4E06	Agricultural Ecology	99	36	4
PSB4E07	Programming for Bioinformatics	81	54	4

Project

In the fourth semester, each student has to undertake a research project and to submit a dissertation. Topic of dissertation may be chosen from any area of botany and may be laboratory-based, field-based or both or computational, with emphasis on originality or approach. It may be started during 2nd / 3rd semester and shall be completed by the end of the 4th semester. The Dissertation should be prepared in a Science Thesis Model. Along with the submission of project dissertation, there will

be a Viva voce and presentation as components of evaluation.

The project work shall be carried out under the supervision of a teacher in the parent department concerned or prescribed by the department coordinator. The project report shall be prepared according to the guidelines approved by the university. Two typed copies of the project report shall be submitted to the Head of the Department, two weeks before the commencement of the ESE of the final semester. The external evaluation of the project work shall be carried out at the end of the programme. Every student has to do the project work independently. No group projects are accepted. The project should be unique with respect to title, project content and project layout. No two project report of any student should be identical, in any case, as this may lead to the cancellation of the project report by the university.

Project Evaluation

The ESE of the project work shall be conducted by two external examiners. The evaluation of the project will be done at two stages: Continuous Assessment (CA) (supervising teacher/s will assess the project and award internal Marks) and External evaluation (by external examiners appointed by the University). Marks secured for the project will be awarded to candidates, combining the internal and external Marks. The internal (CA) to external component (ESE) is to be taken in the ratio 1:4. Assessment of different components of project may be taken as below.

Internal (20% of total)

Component	% of mark
Punctuality	20
Use of data	20
Scheme/Organization of Report	40
Viva-voce	20

External (80% of total)

Component	% of mark
Relevance of the Topic	5
Statement of objectives	10
Methodology/Reference/Bibliography	15
Presentation of Facts / Figures /Language style/Diagrams, etc.	20
Quality of Analysis/Use of Statistical tools	15
Findings and recommendations	10
Viva-Voce	25

Chairman Board of Examinations, may at his discretion, on urgent requirements, can make certain exception in the guidelines for the smooth conduct of the evaluation of project.

Submission of the Project report and presence of the student for viva are compulsory for internal evaluation. For external evaluation the Project report submitted by the student shall be evaluated by the external examiners. No marks shall be awarded to a candidate if she/he fails to submit the Project report for external evaluation. A student shall be declared pass in the Project Report Course if she/he secures minimum 40% marks of the aggregate and 40% separately for external. The student should get a minimum of 40% marks for pass in the project. In an instance of inability of obtaining a minimum of 40% marks, the Project work may be redone and the report may be resubmitted along with subsequent exams through the parent department. There shall be no improvement chance for the Marks obtained in the Project Report.

Viva Voce Examination

At the end of the 4th semester, each student has to attend a comprehensive viva voce which will be based on all the courses taken in the M.Sc. programme. The Viva voce shall be conducted by two examiners. For external viva, both of them shall be external examiners. Appearance of CA and ESE are compulsory and no marks shall be awarded to a candidate if he/she is absent for CA/ESE or both.

Record of Practical Work

A certified record of practical work done by the student should be submitted at the time of each practical examination. The submissions/documentation prescribed in each course also considered as the record of practical work; all of these are also should be submitted for the external evaluation.

Online Courses/Internships/Certificate/Value Added Course/Bridge course

The student can do any type of online course/ internship/ certificate course/ Training Course/ Value Added Course, along with this regular PG programme, which is permissible by the UGC/ Kannur University/ College. All of these are to be done with prior permission of the Head of the parent Department.

External Examinations for theory courses

The End Semester Evaluation (ESE) of each theory course is done through a question paper for 60 marks with 25 questions belonging to Long Essay, Short Essay, Paragraph and Very short answer type questions; out of which 17 questions are to be answered. The model question paper for the core theory courses, with weightage per module is appended.

External Examinations (ESE) for practical courses

The external evaluation of 4 Practical courses is carried out through an examination for each course at the end of even semesters. Each question paper is having maximum marks of 60, of which 12 marks should be for the records/ submissions related to that course. Project Evaluation and General/Course Viva Voce examination also will be conducted at the end of fourth semester. A model of the practical question papers are attached with the syllabus. The Board of Examiners has the flexibility to make necessary changes in the practical question paper, if required. All the records and submissions should be certified *bona fide* before the external practical examination.

GRADING

Seven Point Indirect Relative grading system

Evaluation (both internal and external) is carried out using Mark system. The grading on the basis of a total internal and external marks will be indicated for each course and for each semester and for the entire programme. The guidelines of grading are as follows:

% of Marks (CA+ESE)	Grade	Interpretation	Range of grade points	Class
90 and above	O	Outstanding	9-10	First class with Distinction
80 to below 90	A	Excellent	8-8.9	
70 to below 80	B	Very good	7-7.9	First class
60 to below 70	C	Good	6-6.9	
50 to below 60	D	Satisfactory	5-5.9	Second class
40 to below 50	E	Pass/Adequate	4-4.9	Pass
Below 40	F	Failure	0-3.9	Fail

S.G.P.A = Sum of credit points of all courses in the semester / Total credits in that semester

Credit Point = Grade point (G) x Credit (C)

C.G.P.A = Sum of credit points of all completed semesters / Total credits acquired

O.G.P.A = Sum of credit points obtained in four semesters

Total credits (80)

PASS REQUIREMENT

Course

Candidate securing **E** grade with 40% of aggregate marks and 40% separately for ESE for each course shall be declared to have passed in that course.

Semester

Those who secure not less than 40% marks (both ESE and CA put together) for all the courses of a semester shall be declared to have successfully completed the semester. The marks obtained by the candidates for CA in the first appearance shall be retained (irrespective of pass or fail). The candidates who fail in theory unit shall reappear for theory unit only, and the marks secured by them in practical unit, if passed in practicals, will be retained. A candidate who fails to secure a minimum for a pass in a course will be permitted to write the same examination along with the next batch. For the successful completion of a semester, a candidate should pass all courses and secure a minimum SGPA of 4. However a student is permitted to move to the next semester irrespective of his/her SGPA. A student will be permitted to secure a minimum SGPA of 4.00 required for the successful completion of a Semester or to improve his results at ESE of any semester, by reappearing for the ESE of any course of the semester concerned, along with the examinations conducted for the subsequent admission

IMPROVEMENT

A candidate who secures minimum marks (40%) for a pass in a course will be permitted to write the same examination along with the next batch if he/she desires to improve his/her performance in ESE. If the candidate fails to appear for the improvement examination after registration, or if there is no change/up gradation in the marks after availing the improvement chance, the marks obtained in the first appearance shall be retained. There shall be no improvement chance for the marks obtained in internal assessment. Improvement of a particular semester can be done only once the student shall avail the improvement chance in the succeeding year along with the subsequent batch. There will be no supplementary examinations. For re-appearance/ improvement student can appear along with the next batch.

AWARD OF DEGREE

The successful completion of all the courses prescribed for the Post Graduate degree programme in **Plant Science with Bioinformatics** with E grade (40% of maximum marks) and with a minimum SGPA of 4.0 for all semesters and minimum CGPA 4.0 satisfying minimum credit 80, shall be the minimum requirement for the award of degree. Position certificates up to third position will be issued on the basis of highest marks secured for the programme. In the case of a tie, highest of CGPA is to be considered.

SYLLABUS OF THE M Sc PLANT SCIENCE WITH BIOINFORMATICS PROGRAMME

Semester wise Course Structure and Module wise Hour Distribution

Semester No.	Course No.	Title and Module wise Breakup of the Course	Working Hours	
			Per Semester	Per Week
I	PSB1C01	Cell Biology (1.5) and Molecular Genetics (1.5)	54	3
	PSB1C02	Microbiology (1), Mycology (1.5) and Plant Pathology (1)	63	3.5
	PSB1C03	Phycology (1.5), Bryology (1.5) and Pteridology (1.5)	81	4.5
	PSB1C04	Gymnosperms (1), Angiosperm Anatomy (1.5) and Embryology (1.5)	72	4
II	PSB2C05	Environmental Science (1.5), Forest Botany (0.5) and Phytogeography (1)	54	3
	PSB2C06	Genetics (2), Plant Breeding (1) and Biostatistics (1.5)	81	4.5
	PSB2C07	Evolution (1) Microtechnique (1) and Bioinstrumentation (1.5)	63	3.5
	PSB2C08	Microbial (2) and Plant Biotechnology (2)	72	4
	PSB2P01	Practical I: Cell Biology, Microbiology, Mycology, Plant Pathology, Phycology, Bryology, Pteridology, Gymnosperm Botany, Environmental Science and Forest Botany	180	10
	PSB2P02	Practical II: Angiosperm Anatomy, Embryology, Evolution, Genetics, Biostatistics, Plant Breeding, Bioinstrumentation, Microbial and Plant Biotechnology	180	10
III	PSB3C09	Plant Physiology (3) and Biochemistry (1.5)	81	4.5
	PSB3C10	Angiosperm Morphology(0.5) and Systematics (2.5)	54	3
	PSB3C11	Basic Bioinformatics (3.5)	63	3.5
	PSB3C12	Structural Bioinformatics (4)	72	4
IV	PSB4E01	Elective Course 1 (7.5)	135	7.5
	PSB4E02	Elective Course 2 (7.5)	135	7.5
	PSB4P03	Practical III Angiosperm Morphology, Systematics, Plant Physiology and Biochemistry	180	10
	PSB4P04	Practical IV Basic Bioinformatics and Elective 1 and 2	36	2
	PSB4P05	Project/Dissertation	144	8
	PSB4P06	General/Course Viva Voce	-	-
		Total	450/Sem	25/week

(Total credits for the course: 80; Internal 20%; External 80%
Duration of External Examinations: for theory papers 3hours, for practical papers 4 hours and for Project/Viva 30-45 minutes for each student.)

SEMESTER I

PSB1C01: CELL BIOLOGY AND MOLECULAR GENETICS

Module – 1 CELL BIOLOGY (27 Hrs)

a. **Basic cell structure and cell reproduction (6 Hrs)**: prokaryotes and eukaryotes; structural organization and functions of cell organelles (Cell wall, Plasma membrane, Nucleus, Mitochondria, chloroplast, nucleus, Golgi body, Endoplasmic reticulum, Micro bodies - Glyoxisomes, Peroxisomes, Oxalosomes, Glycosomes, Hydrogenosome and vacuoles). Ribosomes: Different Types (Prokaryotic, Eukaryotic, Cytoplasmic, Organellar, etc.), Polysomes. Cell Reproduction - Mitosis and Meiosis

b. **Cells & their environment (5 Hrs)**: Transport of materials - biosynthetic (secretory) and endocytic pathway. Cell communication - general principles. Signaling molecules and their receptors; external and internal signals that modify metabolism, growth and development of plants. Extra cellular matrix, Cell adhesion molecules - cadherins, integrins, selectins, fibronectins, laminin and immunoglobin superfamily. Cell-cell adhesions - junctional and non-junctional adhesive mechanisms; occluding junctions, anchoring junctions, communicating junctions (connexons and plasmodesmata).

c. **Ultra structure, composition & functions of Nucleus, Mitochondria and Plastids (5 Hrs)**; **Nucleus**: Nuclear Membrane, Nuclear Pore Complex, Nucleolus (NOR), Nuclear Matrix, Nuclear Lamina & Chromatin Assembly Factor (CAF). Nuclear cytoplasmic transport.

   Mitochondira: Structure of ATP Synthase, Chaperones & Chaperonins, Kinetoplast; Mitochondrial Heterosis, Mitochondrial Abnormalities of Plants & Mitochondrial diseases. **Plastids**: Chloroplast Import, Photosynthetic Domains, Chlorophyll Binding Proteins; Chlorosomes & Chromatophores.

d. **Chromosomes: Structure, Chemistry and Organization** (**4 Hrs**) Kinetochore, Satellites, Chromomeres, Chromosome Knobs, Structure and organization of chromatin- Euchromatin, Heterochromatin, prochromatin and antichromatin. Packaging of DNA into chromosomes. structure and role of centromere and telomere. Mitochondrial and plastid genome organization.

e. **Cell cycle and its regulation (7 Hrs)**: Stages of cell cycle (mitosis and meiosis). Spindle formation and its disintegration; Role of cohesions and condensins. Molecular Motors, Microfilaments & Microtubules, Actins & Tubulins, Microtubule Associated proteins (MAP) - Dynein, Dynactin, Kinesin, Kinectin. Regulation of cell cycle: Role of cyclins, cyclin dependent kinases, cdk activating kinases, CDK inhibitory proteins. Apoptosis: Regulatory proteins, extrinsic and intrinsic pathways of apoptosis. Cell signaling for apoptosis.

Module – 2 MOLECULAR GENETICS (27 Hrs)

a. **Basics in Molecular Biology and Genetics (2 Hrs)**: Structure of DNA and RNA - Purines and Pyrimidines, Nucleosides, Nucleotides, Watson and Crick Model of DNA.

b. **Molecular Structure of DNA (4 Hrs):** Topology of DNA, Forms & types of DNA (Super Helical - Circular, Nicked-Circular, Linear, Satellite, selfish), Types of DNA - A, B, C, D, E, H, Z, RL Helix & Triple Helix; Organellar DNA (ct DNA & mt DNA); Replication of DNA: DNA Replication *in vivo*, Types of DNA Replication (Conservative, semi-conservative & dispersive), Enzymology of replication. Replication of ΦX174. Comparison of Eukaryotic and prokaryotic replication.

c. **Gene Expression (3 Hrs)**: Transcription in Prokaryotes, Transcription & RNA Processing in Eukaryotes, RNA Splicing & Spliceosomes, Introns, Intron Homing, Exons, Exon Shuffling, RNA Editing; Structure & Composition of RNA - rRNA, mRNA, tRNA (Clover Leaf Model

& 'L'- Shaped Tertiary Conformation) & snRNA; Genetic Code; Protein Synthesis & Protein Synthesis Inhibitors.

d. **Gene regulation (7 Hrs)**: Prokaryotes - Operon Concept (lac Operon, trp Operon.) Positive and negative control attenuation, anti termination. Gene Expression in Eukaryotes - heterochromatinisation and DNA methylation (DNA methylases, DNA rearrangements). Transcriptional regulation (signal transduction – upstream and downstream, regulatory sequences and transacting factors, activators and enhancers). DNA binding by transcription factors. Britten and Davidson Model for eukaryotic gene regulation. Post transcriptional regulation (RNA processing, split genes, hnRNA, introns and exons, capping, polyadenylation, splicing, snRNAs and spliceosomes, Post transcriptional silencing micro RNAs and RNA inhibition). Translational regulation and post translational regulation (Cleavage and processing of Proteins, Genetic imprinting) Environmental regulation and the concept of epigenetics.

e. **Mutation & DNA Repair Mechanisms (3 Hrs)**: Somatic & Germinal Mutations, Spontaneous & Induced Mutations, Environmental Mutagens, Molecular Basis of Mutation, DNA Repair Mechanisms (Light-Dependant-, Excision-, Mismatch-, Post Replication- & SOS Repair). Methods to detect mutation (ClB method, attached X method, Ames test).

f. **Chromosomal aberrations (5 Hrs)**: Duplications, deficiencies/deletions, inversions, interchanges/ translocations; Role of chromosomal aberrations in crop evolution; Ploidy changes: Haploids, polyploids and aneuploids; Genome analysis in crop plants; Molecular Cytogenetics: FISH, GISH, FIBER-FISH, Flow Cytogenetics, Flow karyotyping, Applications of molecular cytogenetics.

g. **Molecular genetics of Human and Cancer (3 Hrs)**: Major Human Genetic Abnormalities, Syndromes and Diseases (ADA deficiency, Nail Patella Syndrome, Blooms Syndrome, *Xeroderma pigmentosum*, retinoblastoma, Sickle Cell Anemia), HGP and its relevance in Human Welfare. Cancer - Tumor suppressor genes, Genetic basis of malignant transformation, oncogenes, cancer and cell cycle, chromosome rearrangements and cancer, Pathways of Cancer.

Practicals

1. Preparation of mitotic spreads and analysis of various stages of cell division (*Allium* and *Rhoeo*) with special emphasis to Metaphase and Anaphase.
2. Study of mitotic index in different conditions given for onion root growth
3. Study of meiosis in *Datura/Rhoeo/Chlorophytum/Crotalaria* by smear preparation of PMCs.
4. Camera Lucida drawings of Karyotype from a permanent slide.
5. Demonstration of Karyotyping using common/crop plants (Onion, *Rheo*)
6. Study of giant chromosomes in *Drosophila*.
7. Colorimetric estimation of DNA by Diphenylamine method.
8. Colorimetric estimation of RNA by Orcinol method.
9. Extraction, isolation and staining of nucleic acid DNA/RNA from plant tissues (leaf/fruit tissue) (CTAB).

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9. Karp, G. 2004. Cell and Molecular Biology: Concepts and experiments. 4th Edition. Wiley.
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11. Lewin B, 2008. Genes IX, Jones and Barlett Publishers. Singh RJ, 2002. Plant Cytogenetics, 2nd edition, CRC Press.
12. Lodish H., Berk, A., Kaiser C. A & Kreiger M., 2012. Molecular Cell biology 7th Edition, W H Freeman, NY, USA.
13. Morris, K.V. 2008. RNA and the regulation of gene expression: A hidden layer of complexity. Caister Academic Press.
14. Pon, L.A. & Schon, E.A. 2001. Mitochondria. Academic Press.
15. Scicchitano, D. 1998. Molecular Cell Biology W. H. Freeman & Co.
16. Turner, B.M. 2002. Chromatin and Gene Regulation. Blackwell Publishing Co.
17. Weaver R. F., 2008. Molecular Biology, Mac Graw Hill, New York.
18. Weising K, Nybom H, Wolff K & Kahl G., 2005. DNA Fingerprinting in Plants: Principles, Methods and Applications, 2nd ed. Taylor and Francis Group, Boca Raton, FL.

SEMESTER I

PSB1C02: MICROBIOLOGY, MYCOLOGY AND PLANT PATHOLOGY

Module – 1: MICROBIOLOGY (18hrs)

a. **Basics in Microbiology (3 Hrs)**: History of Microbiology, Contribution of Indian Microbiologists - J V Bhat, M K Patel and Jay Vakil. General classification of microbes, Economic importance of microbes.

b. **Methods in Microbiology (5 Hrs)**: for screening and identification of various microbe groups; microbial culture - culture media and their preparation for microbes - bacteria and viruses; methods of sterilization, isolation of pure cultures, cultivation of anaerobic bacteria, maintenance of microbial cultures, estimation of microbial number and biomass, bacterial staining. Genomes based classification of Microbes and their phylogeny.

c. **Bacteria (5 Hrs)**: Classification of Bacteria according to Bergey's manual of systematic bacteriology (up to family). Systematic identification of bacteria: Phenotypic - morphology, motility, colony characters, biochemical tests and molecular techniques used in bacterial identification.

- Major groups of Bacteria: Spirochetes, Rickettsias, Chlamydias, Mycoplasmas, Actinomycetes. DNA Barcoding in bacteria, Myxobacteria, Archaebacteria: - extremophiles, thermophilic, halophilic, acidophilic, alkalophilic bacteria and methanogenic bacteria
- Ultra structure of Gram positive and Gram negative bacteria; cell membrane, cell wall, flagella, pili, fimbriae, capsule and slime, ribosome and endospores. Bacterial genetics and plasmids.
- General outline on Nutrition, cultivation, growth of Bacteria.

d. **Viruses (2 Hrs):** General account of plant and animal viruses and bacteriophages; classification of viruses; Viral cryptogram. Detailed study of plant viruses including their morphology, structure, isolation, purification, assay, infection, replication and transmission; viroids and prions.

e. **Applications of Microbial Fermentation and Agricultural microbiology (3 Hrs)**: Industrial microorganisms and products, primary and secondary metabolites, production of alcohol, vinegar, antibiotics, vitamins, steroids, vaccines, organic acids, enzymes, fermentation technology - fermentor design and operation, upstream and downstream processes, Management of agricultural soils, biofertilizers and biopesticides.

Practicals

1. Isolation of bacteria from soil: Serial dilution - pour plate/spread plate method.

2. Staining of bacteria and their spores.

3. Isolation of *Rhizobium* from root nodules and its Gram staining.

4. Demonstration of bacterial motility by hanging drop method.

References:

1. M. Goodfellow *et al*. 1983. The Biology of Actinomycetes. Academic Press.

2. Madigan, M. T. *et al*. 2008. Brock Biology of Microorganisms. Benjamin Cummings.

3. Pelczar, M.G, Chan E.C.S. & Krieg N.R. 1986. Microbiology, Tata McGraw Hill.

4. Prescott, L. M. *et al.* 2005. Microbiology. McGraw Hill.

5. R.E.F. Mathew. 1991. Plant Virology, 3rd ed. Academic Press.

6. R.Y. Stanier *et al*. 1990. The Microbial World. Prentice Hall.

7. Singleton, P. 2004. Bacteria in Biology, Biotechnology and Medicine. Wiley.

Module – 2: MYCOLOGY (27 Hrs)

a. **Basics in Mycology (5 Hrs)**: History of Mycology, Contribution of Indian Mycologists - Butler, Kirtikar and Subramanian C V. General characteristics of fungi: thallus organization, modes of nutrition, structure of fungal cell wall. Economic importance of Fungi

b. **Classification of Fungi (5 Hrs)**: Kingdoms of fungi: Fungi, Chromista, Protozoa; phylum-level classification Alexopoulos *et al.* 1996, and Kirk *et al.* (2008); Characters used in fungal classification, DNA Barcoding in fungi.

c. **General characteristics and classification of the following phyla (10 Hrs)**: General characters, habit and importance of asexual fungi, somatic structures, and reproductive structures in Myxomycota, Oomycota, Chytridiomycota, Zygomycota, Glomeromycota, Ascomycota and Basidiomycota. Asexual fungi (Deuteromycetes).

- Growth of fungal thallus, fungal tip growth, vegetative incompatibility and sexual compatibility, parasexuality. Types of fruiting bodies in fungi.
- Fungal metabolic pathways, secondary metabolic pathways, Mycotoxins, Aflatoxins, Amatoxin, Ergot, Fusarin and antibiotics.

d. **Economic importance and Ecological significance of Fungi (4 Hrs)**: Fungi as symbionts: mycorrhizae, endophytes, insect–symbionts; Role of fungi in decomposition of cellulose and lignin, mechanism of decomposition by fungi.

e. **Lichens (3 Hrs)**: Classification, Habitat ecology, thallus structure, nutrition, reproduction, mutualistic interaction, ecological and economic significance.

Practicals

1. Using appropriate mycological methods and techniques the students shall collect and study the morphology and anatomy of the reproductive structures of the following genera of fungi *Stemonites, Synchytrim, Saprolegnia, Albugo, Pilobolus, Mucor, Saccharomyces, Taphrina, Erysiphe, Ascobolus, Xylaria, Geoglossum, Phomopsis, Drechslera, Aspergillus, Alternaria, Cercospora, Fusarium, Pleurotus, Auricularia, Ustilago, Ganoderma, Lycoperdon, Geastrum, Dictyophora, Cyathus, Parmelia* and *Usnea*.

2. Isolation of fungi from soil and water by culture plate technique

3. Collection, identification and submission of 5 locally available genera with photographs/or description.

References:

1. Alexopoulos, C.J. *et al*. 1996. Introductory Mycology, 4th Edition, Wiley.

2. Carlile, M.J. & Watkinson, S.C. 2001. The Fungi. Academic Press.

3. Deacon, J.W. 2005. Introduction to Modern Mycology, Blackwell.

4. Jennings, D.H. & Lysek, G. 1999. Fungal Biology. Bios Scientific Publishers.

5. Kavanagh, K. (ed.) 2005. Fungi – Biology and Applications. Wiley.

6. Moore–Landecker. 1996. Fundamentals of Fungi. Cambridge University Press.

7. Nash, T.H. 1996. Lichen Biology. Cambridge University Press.

8. Webster, J. and Weber, R. 2007. Introduction to Fungi. Cambridge University Press.

Module – 3: PLANT PATHOLOGY (18 Hrs)

a. **Basics of Plant pathology (3 Hrs):** of plant diseases causes and classification; Common agents of

plant diseases, Common Symptoms of plant diseases. Koch postulates. History of Plant Pathology and Contribution by Indian phytopathologists - K C Mehta, B B Mundkar.

b. **Disease development (3 Hrs)**: infection, progress of disease, role of enzymes and toxins; Defense mechanisms: structural and chemical; Effect of environment on plant disease development.

c. **Plant disease management (5 Hrs)**: control measures that exclude or eradicate pathogen, direct protection of plants from pathogens by biological control and chemical control, types of chemicals used for plant disease control, regulatory methods, control through use of transgenic plants, integrated control of plant diseases.

d. **Major Diseases of plants in India(7 Hrs)**:

- Cereals: Rice – blast disease, bacterial blight and Brown spot
- Vegetables: Tomato - Bacterial wilt; Chilly - leaf spot; *Abelmoschus* - Yellow vein mosiac.
- Fruits: Banana – bunchy top; Mango – Anthracnose; Papaya – mosaic.
- Spices: Ginger – rhizome rot; Pepper – quick wilt; Cardamom - Mosaic disease.
- Oil seeds: Coconut – grey leaf spot, bud rot disease.
- Rubber yielding crops: *Hevea braziliensis.* Abnormal leaf fall and powdery mildew.
- Sugar yielding crops: Sugarcane – red rot.
- Cash crops: Arecanut – nut fall disease. Cashew nut: Gummosis.
- Beverage crops: Tea – blister blight and Red rust; Coffee – rust.
- Tuber crops: Tapioca - mosaic virus; Elephant Foot yam - Collar rot.

Practicals

1. Study of the following diseases with reference to signs and symptoms in the laboratory and collection of 5 locally available plant disease specimens.

2. Isolation of pathogens from diseased tissues (leaf, stem, fruit and seed) by blotter / culture methods.

3. Blast disease of Rice, black rust disease of Wheat, Chilly – leaf spot; okra – leaf spot disease, Banana – bunchy top; Mango – Anthracnose; *Citrus* - bacterial canker; Ginger – rhizome rot; Pepper – quick wilt; Tikka disease of ground nut, Coconut – grey leaf spot, bud rot disease. *Hevea braziliensis* – abnormal leaf fall, powdery mildew. Sugarcane – red rot, Arecanut - nut fall disease, cassava mosaic, Coffee – rust.

References:

1. Agrios G.N. 2005. Plant pa*thology, 5th ed. Ac*ademic Press.

2. Lucas, J.A. 1998. Plant Pathology and Plant Pathogens, 3rd ed. Blackwell.

3. Mehrothra R.S. 1980. Plant Pathology. Tata-McGraw Hill

4. Smith K.M. 1973. A text book of plant virus diseases, 3rd ed. Academic Press.

5. Rangaswami G. 1988. Diseases of crop plant of India, 3rd ed. Prentice Hall, India

6. Scheffer, R.P. 2007. The Nature of Disease in Plants. Cambridge University Press.

7. WaIler, J.M., Lenne J.M. and WaIler S.J. (Ed.) 2001. Plant Pathologists' Pocketbook.

SEMESTER I

PSB1C03: PHYCOLOGY, BRYOLOGY AND PTERIDOLOGY

Module – 1: PHYCOLOGY (27 Hrs)

a. **Basics in Phycology (5 Hrs):** General features of algae and comparison with other groups: diversity in thallus and cell structure, pigments and stored food materials in algae, various asexual, vegetative and sexual methods of reproduction in algae, Life cycles in algae. Economic importance of algae. History of Phycology: Contributions of Indian Phycologists: M O P Iyengar, T. V. Desikachary, V. K. Krishnamurthy, M. S. Balakrishnan, G. S. Venkataraman.
b. **Classification of Algae (5 Hrs)**: Comparison of systems of classification of F. E. Fritsch and van den Hoek *et al*. (1995) system and Lee (2008). Modern trends in algal classification-DNA barcoding in algae.
c. **General characters of Algae (10 Hrs):** Habit, Habitat, Thallus structure, cell structure, reproduction and Lifecycle in Cyanophyta, Chlorophyta, Xanthophyta, Bacillariophyta, Phaeophyta, Rhodophyta, Euglenophyta, Dinophyta, Chrysophyta and Cryptophyta.Pigmentation and stored food materials; Types of nutrition;
d. **Evolution and Algae (2 Hrs)**: Parallelism in evolution, theories and hypotheses on origin of higher plant groups from algae.
e. **Ecology (3 Hrs):** Ecology of freshwater forms and marine forms. Algae and pollution, Algae as indicators. Algal bloom. Significance of algae in budgeting of elements and biogeochemical cycles. Algal Toxicity - ASP, NSP, PSP and Cynobacterial toxins.
f. **Methods and techniques (4 Hrs)** of collection, preservation and staining of Algae. Algal culture: Importance, various methods and media.

Practicals

1. Collection, preservation and identification up to generic level.

   Cyanophyta: *Gloeocapsa, Oscillatoria, Microcoleus, Anabaena, Nostoc, Scytonema, Stigonema.*

   Chlorophyta: *Chlorella, Hydrodictyon, Scenedesmus, Enteromorpha, Ulva, Pithophora, Bulbochaete, Cephaleurous, Chaetophora, Acetabularia, Bryopsis, Codium, Caulerpa, Halimeda, Desmids - Closterium, Cosmarium, Mougetia, and Nitella.*

   Xanthophyta: *Botrydium.*

   Bacillariophyta: *Coscinodiscus, Odontella.*

   Phaeophyta: *Ectocarpus, Dictyota, Padina, Porphyra.*

   Rhodophyta: *Batrachospermum, Gracilaria, Gelidium.*

2. Collection, preservation and preparation of five algal herbarium specimens
3. Field visit and submission of 10 photographs of microalgae and macroalgae from field visits.
4. Staining Techniques for permanent mounts.
5. Algal culture practice

References:

1. Barsanti, L. & Gualtieri, P. 2007. Algae: Anatomy, Biochemistry, and Biotechnology. CRC Publishers.
2. Bold & Wayne. 1978. Introduction of Algae. Prentice-Hall.
3. Das S K & Adhikary S B, 2014. Freshwater Algae of Eastern India. Astral Inernational.
4. Fritsch, F.E. 1945. The structure and Reproduction of Algae. Vol. 1 and 2. Cambridge University Press.
5. Graham and Wilcox. 2000. Algae. Benjamin Cummings.
6. Round, F.E. 1965. The biology of Algae. Edward Arnold.
7. Smith G. M., Cryptogamic Botany Volume I.
8. Smith, G.M. 1950. Manual of Phycology. Chronica Botanica Co.
9. Tomas, C.R, 1997. Identifying Marine Phytoplankton. Academic press.
10. van den Hoek, C., Mann, D.G. & Jahns, N.M. 1995. Algae: An Introduction to Phycology. Cambridge University Press.

Module – 2: BRYOLOGY (27 Hrs)

a. **Basics in Bryology (10 Hrs):** General features of Bryophytes, Comparison with other groups, History of Bryology, Contributions of Indian bryologists: S R Kashyap, S K Pande and Ram Udar. Methods and techniques in bryophyte Studies: Ecological and Economic importance of bryophytes.
b. **Classification of Bryophytes (3 Hrs)**: Comparison of Rothmaler 1951 and Goffinet et al 2008. Modern trends in classification - DNA barcoding.
c. **Reproduction (3 Hrs)**: different types of reproduction, life history patterns, Origin and evolution of Bryophytes.
d. **General characteristics (11 Hrs)**: Anatomy, reproduction, life history and phylogeny of Spherocarpales, Marchantiales, Jungermaniales, Anthocerotales, Funariales and Polytricales.

Practicals

1. Morphological and structural study of representation members of following groups using cleared whole mount preparations, dissections and sections: *Cyathodium, Lunularia, Targionia, Porella,, Sphagnum, Bryum* and *Polytrichum.*
2. Field trip to observe bryophyte diversity.

References:

1. Cavers, F. 1911. The interrelationship of Bryophytes. New Phytologist.
2. Chopra R N & P K Kumar, 1988. Biology of Bryophytes. Wiley Eastern Ltd.
3. Dyer A F, & J G Duckett (Eds) (1984). The experimental Biology of Bryophytes. Academic Press.
4. Glime, J M, et al., 2020, Bryophyte Ecology - ebook in 5 volumes. https://digitalcommons.mtu.edu/oabooks/4/
5. Kashyap, S.R. 1921. The Liverworts of Western Himalaya and the Punjab Plains, Vol. I & II. Chronica Botanica.
6. Parihar, N.S. 1965. An introduction of Embryophyta: Bryophyta, General Book House, Allahabad.
7. Shaw, A.J. & Goffinet, B. 2000. Bryophyte Biology. Cambridge University Press.
8. Smith, G.M. Cryptogamic Botany Vol. II. McGraw Hill. Book Co. N.Y.
9. Smith A J E, 2011. Bryophyte Ecology, Springer.
10. Udak R, 1976. Bryology in India. Chronica Botanica Co.
11. Verdoon, F.M. 1932. Manual of Bryology. Ashor & Co. Amsterdam.
12. Watson, E.V. 1971. The structure and life of Bryophytes, Hutchinson Univ. Press London.

Module – 3: PTERIDOLOGY (27 hrs)

a. **Basics in Pteridology (5 Hrs):** History of Pteridology: General features of Pteridophytes, Comparison with other groups, Pteridophyte herbarium preparation, cultivation techniques and spore staining and spore germination. Contributions of Indian Pteridologists: RH Beddome, B K Nair and V S Manickam.
b. **Classification of Pteridophytes (2 Hrs):** Comparison of various systems of classification. Modern trends in classification - DNA barcoding.
c. **Reproduction (10 Hrs)**: different types of reproduction, life history patterns, Origin and evolution of Pteridophytes. Origin and evolution of sporangium – heterospory and seed habit. Development and evolutionary trends in the gametophytes of Pteridophytes. Evolution of vascular tissue - theories and concepts.
d. **General characteristics (7 Hrs)**: Anatomy, reproduction, life history and phylogeny of Psilopsida, Lycopsida, Sphenopsida and Pterospida; with special reference to South Indian species.

   Fossil Pteridophytes, Psilophytales, Lepidodendrales Calamitales, and Primofilicales

e. **Ecological and Economic importance of pteridophytes (3 Hrs):** Habitat ecology of Pteridophytes - epiphytes, lithophytes, climbers, halophytes, sciophytes, xerophytes, rheophytes, hydrophytes. Pteridophytes as weeds – *Salvinia* (Aquatic) *Pteridium* (Terrestrial), weed problem, weed control – impact and management – Biological control. Ornamental and medicinal Pteridophytes. Pteridophytes as ecological indicators. Nitrogen fixation by Pteridophytes

Practicals

1. Morphological anatomical and reproductive features of *Lycopodium*, *Isoetes*, *Ophioglossum, Angiopteris, Osmunda, Lygodium, Ceratopteris, Pteris, Blechnum, Asplenium, Trichomanes, Acrostichum* and *Azolla.*
2. Fossils – *Rhynia, Lepidodendron, Calamites, Sphenophyllum.*
3. Spore germination and development of prothallus in Knop's agar medium.
4. Field trips to familiarize with the diversity of Pteridophytes in natural habitats and submit a report.
5. Habitat study of *Lycopodium, Gleichenia, Actiniopteris, Pyrrosia, Drynaria, Acrostichum* and *Salvinia*.
6. Submission of 5 herbarium specimens of locally available pteridophytes.

References:

1. Benniamin, A. & Sundari, S. M., 2020. Pteridophytes of Western Ghats: A Pictorial Guide,.Om Publications, New Delhi.
2. Bierhost, D.W. 1971. Morphology of Vascular Plants, Mac. Millan Co., New York.
3. Chandra, S. & Srivastava, M. 2003. Pteridology in the New Millennium. Kluwer Academic Publishers.
4. Dyer, A.C. 1979. The experimental Biology of Ferns. Academic Press, London.
5. Jermy, A.C. 1973 (Ed.). The Phylogeny and Classification of Ferns.
6. Kramer, K.U. and Green, P.S. 1991. The Families and Genera of Vascular Plants, Narosa, New Delhi; ISBN 978-3-662-02604-5.
7. Sporne, K. R 1966. The Morphology of Pteridophytes: The Structure of Ferns and Allied Plants. Hutchinson.

SEMESTER I

PSB1C04: GYMNOSPERMS, ANGIOSPERM ANATOMY AND EMBRYOLOGY

Module – 1 GYMNOSPERMS (18 Hrs)

a. **Basics in Gymnosperm Botany (5 Hrs)**: General features of the gymnosperms and comparison with other groups. Ecological significance and Economic importance of gymnosperms. Distribution of living and fossil gymnosperms in India. History of Gymnosperm botany, Contributions of Indian gymnosperm botanists - Birbal Sahni and Bharadwaj.

b. **General characters of Gymnosperms (13 Hrs)**:

- Classification (Sporne, 1965) and moderns trends including molecular phylogeny.
- Distribution, morphology, anatomy and reproductive biology and phylogenetic trends in the following orders of gymnosperms: Pteridospermales, Glossopteridales, Caytoniales, Cycadoideales, Pentoxylales, Cycadales, Ginkgoales, Coniferales, Taxales, Ephedrales, Welwitschiales and Gnetales.

Practicals:

1. Identification of fossil gymnosperms - *Lyginopteris, Heterangium, Medullosa* and *Glossopteris.*
2. Comparative study of vegetative and reproductive structures of the living genera mentioned below. *Zamia, Cedrus, Cryptomeria, Cupressus, Agathis, Podocarpus, Ephedra* and *Gnetum.*
3. Conduct field trips to familiarize various gymnosperms in nature and field identification of Indian gymnosperms and submit a report.

References:

1. Andrews, H.N. 1961. Studies in Paleobotany, Wiley.
2. Banks, H.P. 1970 Evolution and plants of the past. Wadsworth.
3. Bierhost, D.W. 1971. Morphology of vascular plants, Macmillan.
4. Bower F.O. 1935. Primitive plants. Macmillan.
5. Byng, J. W. 2015. The Gymnosperm Handbook, Plant Gateway Ltd.
6. Chamberlain, C.J. 1935. Gymnosperms Structure and Evolution. Univ. of Chicago Press.
7. Christenherz M.J.M, Reveal J.L., Farjon A, Gardner M.F. & Mill R.R.M. 2011. A new classification and linear sequence of extant gymnosperms, *Phytotaxa*19: 55-70.
8. Foster, A.S. & E.M. Gifford. 1974. Comparative morphology of vascular plants. Freeman.
9. Maheshwari, P & V. Vasil. *Gnetum*. CSIR, New Delhi.
10. Ramanujam, C.G.K. 1976. Indian Gymnosperms in time and Space. Today & Tomorrow's Printers & Publishers, New Delhi.
11. Stewart, W.N. 1983. Paleobotany and the evolution of plants. Cambridge Univ. Press.
12. Stockey, R.S. 1981. Some comments on the origin and evolution of conifers. Canadian J. Bot. 59: 75-82.
13. Taylor, T.N. 1982. Reproductive biology in early seed plants. Bioscience 32: 23-28.
14. Walton, J.1953. An introduction to the study of fossil plants. A & C Black, London.

Module – 2 ANGIOSPERM ANATOMY (27 Hrs)

a. **Basics in Anatomy (3 Hrs)**: Structure and Functions of Tissues - meristems; permanent Tissues - simple (parenchyma, collenchyma and sclerenchayma) and complex tissues (xylem and phloem). Tissue systems (Epidermis, ground and Vascular) of primary root, stem and leaf - types and variations tissue History of plant anatomy: Scope and significance, interdisciplinary relations.

b. **Major concepts and theories in Anatomy (10 Hrs)**: Differentiation and its significance in developmental studies. Dedifferentiation and redifferentiation.

- Recent theories on organization of root and shoot apical meristems. Origin of lateral root. Leaf and bud development. Plastochronic stage, experimental studies on meristems, vegetative to reproductive apex. Reversion from reproductive to vegetative apex.
- Environmental factors influencing differentiation of the divergent tissue systems, experimental studies, and their economic importance.
- Origin, structure and function of cambia and its derivatives. Concept and classification. Cambium in wound healing and grafting, factors influencing cambial differentiation and activity. Cork cambium - origin, types, derivatives and function.
- Abnormal Cambium: Classification, origin and function, experimental studies.

c. **Xylem and Phloem (2 Hrs)**: Origin and trends of specialization. Taxonomic significance, factors affecting xylem and phloem differentiation.

d. **Roots (1 Hr):** Initiation and development of specialized roots.

e. **Anatomy of seedlings (3 Hrs):** Root Stem transition - features and types; Nodal anatomy - features and types; Controversies on phylogenetic trends in nodal anatomy and root stem transition.

f. **Leaf (1 Hr)**: Origin and development of lamina **–** general pattern and phyllotaxy.

g. **Fruit and seeds (3 Hrs)**: General anatomy of fleshy and dry fruits; Anatomy of seeds in general, development dormancy and drought resistance from anatomical point of view.

h. **Applied anatomy (4 Hrs)**: Wood anatomy of economically important plants - Teak, Jack, *Dalbergia, Ailanthus* and *Alstonia*. Applications of anatomy in systematics (histotaxonomy) and Pharmacognosy. Research prospects in anatomy

Practicals

1. Variations in Epidermis **–** Trichomes, stomatal types; estimation of stomatal index.
2. Types of Nodal anatomy and Root - stem transition
3. Maceration of Xylem in herbaceous and woody stems to separate different cell types.
4. Abnormal secondary growth **–** different patterns: *Bignonia*, *Aristolochia, Amaranthus, Nyctanthes, Aerva, Mirabilis, Piper, Bougainvillea* and *Strychnos.*

References:

1. Clive K., 2016. Plant Anatomy, Morphology and Physiology, Syrawood Publishing House.
2. Crang, R., Wise, R. & S. L. Sobaski, 2018. Plant Anatomy - A concept based approach to the structure of Plants, Springer.
3. Cutler D. F., Ted Botha T., & Stevenson D W, 2016. Plant Anatomy – an applied approach, John Wiley and Sons.
4. Cutter, E.G. & Edward, E. 1978. Plant Anatomy: Experiment and Interpretations Part 1 & 2. Edward Arnold.

5. Dickison W. C., 2000. Integrative Plant Anatomy, Harcourt Academic Press.
6. Eames A. J. & Mc Daniels, L.H. 1979. An Introduction to plant Anatomy, Mac Graw Hill New York.
7. Esau, K. 1983. Plant anatomy. Wiley Eastern Limited.
8. Fahn, A. 1977. Plant anatomy. Pergamon Press.
9. Forester, A.S. 1960 Practical Plant anatomy. D. Van Nostrand Company Inc.
10. Mauseth, J.D. 1988. Plant anatomy. The Benjamin Cumming Publishing Co.
11. Roberts, L.W. 1976. Cytodifferentiation in plants. Cambridge University Press.
12. Pijush Roy. 2010. Plant Anatomy. New Central Book Agency (P) Ltd, London.

Module – 3 ANGIOSPERM EMBRYOLOGY (27 Hrs)

a. **Basics in Angiosperms Embryology (5 Hrs)**: Basic structure of sex organs in a flower, Structure and function of wall layers in the anther; structure and development pattern in microsporangium and megasporagnium, double fertilization and triple fusion; post fertilisational changes and endosperm development.

b. **Pollen development (3 Hrs)**: Role and ultra structural changes of tapetum in pollen development. Male gametophyte: Microspore/pollen mitosis, division of generative cell heterogenicity in sperms, pollen fertility and sterility, pollen storage, viability and germination.

c. **Palynology (5 Hrs)**: Pollen morphology, ultrstructure of pollen wall, palynogram, evolution of pollen types. Contributions of G Erdtman, PKK Nair. Applied palynology - mellito palynology, aeropalynology, paleo palynology and forensic palynology. Application of Palynology in Taxonomy. Economic and ecological importance of pollen grains - pollen biology, pollen allergy and productivity.

d. **Ovule and megasporogenesis (3 Hrs)**: Ovular Ontogeny, types and evolution, reduction, nutrition. Sub-cellular features of archesporial and megaspore mother cells, megaspore tetrad, dyad and coeno megaspore, termination of functional megaspore. Female gametophyte - Embryosac: Classification and types, ultra structure of components; synergids and antipodal haustoria, nutrition of embryo sac.

e. **Molecular biology of micro and megasporogenesis (2 Hrs)**: interaction of mitochondrial and nuclear genes; signal transduction at the level of stigma style and ovules; physicochemical aspects of pollination; pollination energetic.

f. **Pollination (3 Hrs)**: Primary and secondary attractants of pollination. Ultrastructural histochemical details of style and stigma, significance of pollen-pistil interaction, role of pollen wall proteins and stigma surface proteins, intra - ovarian pollination and in vitro fertilization. Coevolution of Pollinators and flowers with special emphasis on major pollination mechanisms.

g. **Fertilization and post-fertilization development (4 Hrs)**: Role of synergids, filiform apparatus, heterospermy, differential behavior of male gametes, syngamy and triple fusion, post fertilization metabolic and structural change in embryo sac.

- **Endosperm**: Classification and types, ultrastructure, cellularisation in nuclear endosperm, endosperm haustoria, their extension and persistence, function, storage metabolites.
- **Embryo**: Polarity in relation to development, classification and types, Histo- and organogenesis of mono- and dicot embryos, delayed differentiation of embryo structure, cytology and function of suspensor, physiological and morphogenetic relationship of endosperm and embryo.

- **Polyembryony and Apomixis**: Classification and types of polyembryony and Apomixis:. Factors affecting polyembryony and apomixes. Diplospory, Apospory, Adventive Embryony, Agamospermy and parthenogenesis of embryos.

h. **Fruit and seed (2 Hrs)**: Fruit and seed development: morphological, anatomical and biochemical changes. Parthenocarpy — induction of seedless fruits.

Practicals

1. Preparation of dissected whole mounts of micro and mega sporangium; pollinia and embryos.
2. Pollen germination - *in vitro* and *in vivo* viability tests.
3. Acetolysis of pollen grains to study the different types of exine ornamentation.
4. Intra-ovarian pollination.
5. Developmental stages of anther, ovule, embryo and endosperm.
6. Study of types of embryo sacs during apomictic development by employing ovule-clearing method.

References:

1. Beck, B. C, 2010. An Introduction to Plant Structure and Development - Plant Anatomy for the Twenty-First Century. Cambridge University Press.
2. Bhojwani S.S. & Bhatnagar S.P. 1974. The embryology of angiosperms. Vikas publication, New Delhi.
3. Bouman F. 1978. Ovule initiation, ovule development and seed coat structure in angiosperms. Today and Tomorrow publishers, New Delhi.
4. Davis C.L. 1965. Systematic embryology of angiosperms: John Wiley, New York.
5. Dickison W. C. 2000. Integrative plant anatomy. Academic Press.
6. Eames A.J. 1960. Morphology of angiosperms. McGraw Hill. New York.
7. Faegri K & van der Pijl L, 1979. The Principles of Pollination Ecology. Pergamon Press, Oxford.
8. Johanson D. 1950. Plant embryology, Waltham, Massachusetts.
9. John B.D. (ed) 1984. Embryology of angiosperms. Springer Verlag, Berlin.
10. Maheswari P. 1950. An introduction to the embryology of angiosperms. McGraw Hill, New York.
11. Raghavan V. 1997. Molecular Embryology of Flowering Plants, Cambridge Univ. Press.
12. Raghavan V. 2000. Developmental Biology of Flowering Plants, Springer Verlag, New York.
13. Raghavan V. 1976. Experimental embryogenesis in plants, Academic Press, New York.
14. Scott, R. J. & Stead, A. D., 2008. Molecular and Cellular Aspects of Plant Reproduction. Society for Experimental Biology, Seminar Series 55.
15. Shivanna K. R. & Rangaswamy N. S. 1992. Pollen Biology: A Laboratory Manual, Springer Verlag, Berlin.
16. Wardlaw C.W. 1976. Embryogenesis in plants. Methusen, London.

SEMESTER II

PSB1C05: ENVIRONMENTAL SCIENCE, FOREST BOTANY AND PHYTOGEOGRAPHY

Module 1 ENVIRONEMNTAL SCIENCE (27 Hrs)

a. **Basic concepts in Ecology (5 Hrs)**: Structure and Function of Ecosystem **–** Structural components, relationship between structural and function; trophic structures, Significance of habitat, ecological niche. Functions of Ecosystems: Biogeochemical cycles; Productivity and energy flow**.** Ecological Succession, climax and stability **–** concepts, characteristics of pioneer and climax species. Major Concepts in Ecology: Ecosystem Equilibrium and Nature's Balance.

b. Autecological concepts - Population Ecology (5 Hrs) (a) Characteristics of populations - size and density, dispersion, age structure, natality and mortality. (b) Population growth, factors affecting population growth, environmental resistance, biotic potential, carrying capacity, positive and negative interaction, migration, subsistence density. Ecological consequence of overpopulations. (c) Genecology - ecological amplitude, ecads, ecotypes, ecospecies, coenospecies.

c. Synecological concepts - Community ecology (5 Hrs) (a) Ecological processes of community formation, ecotone, edge effect. Classification of communities - criteria of classification, dynamic system of classification by Clement. (b) Special plant communities - quantitative, qualitative and synthetic characteristics of plant communities, coefficient of communities; Sorenson's Index of similarity. (c) Dynamic community characteristics - cyclic replacement changes and non-cyclic replacement changes.

d. Dynamic Ecology (3 Hrs) (a) The concept, definition and reasons of succession. Classification of succession: changes - autogenic and allogenic, primary and secondary, autotrophic and heterotrophic. (b) Retrogressive changes or the concept of degradation, concept of climax or stable communities, resilience of communities.

e. Pollution Ecology (5 Hrs). Types of Pollutants, Concept of Pollutant and waste. Types of pollutants and wastes in Land pollution, Water pollution and Air pollution. Noise, Radioactivity, Temperature, Light and Electromagnetc waves as pollutants. Effects of pollution on Ecosystem, Biodiversity and Health issues related to human and plants. Methods to control pollution: Bioremediation, Phytoremediation, bioaugmentation, biofilms, biofilters, bioscrubbers and trickling filters.

f. **Conservation Ecology (4 hrs)**. Concept of endemism, rare, endangered and threatened (RET) species, key stone species, IUCN account of biodiversity, red data book and hot spots, reasons to stop extinction, methods to save species. Biodiversity conservation: Principles of conservation – *ex situ* and *in situ* conservation techniques. Species diversity, community diversity, ecosystem diversity and landscape preservation. UN decade on ecosystem restoration. Role of biotechnology in conservation of species. Ecotourism and its significance

Practicals

1. Analysis of water quality for: (a) Dissolved CO_2 (b) Dissolved oxygen (c) Quantitative estimation of dissolved chloride ions (d) Dissolved sulphate (f) Total alkalinity.

2. Physico-chemical analysis of soil: (a) Total water soluble mineral ions (b) estimation of soil organic carbon (Walkey and Black method).

3. Quantitative and qualitative community analysis. Carry out a project on species structure and the frequency, abundance, density of different species, IVI and similarity index of different communities in a natural system. Students must be able to explain the structure of vegetation from the given data on the above mentioned characteristics.

4. Phytoplankton counting using Sedgwick Rafter counter/ Hemocytometer /Any other counting chambers.

5. Field visit to natural ecosystem and identification of trophic levels, food webs and food chains, plant diversity (species and community).

6. Students should be aware of the common environmental problems, their consequences and possible solutions.

7. Visit to a wild life sanctuary/ National Park

8. Short term Course in Climate change/ Disaster Management/ Conservation Biology can be carried out.

References:

1. Agarwal, V.P. 1988. Forests in India. Oxford & IBH Publishing Co. Pvt. Ltd.

2. APHA, AWWA, WEF, 2012. Standard methods for the examination of water and waste water.

3. Clarks, G.L. 1954. Elements of Ecology. John Wiley & Sons.

4. Cox, G.W. 1969. Readings in Conservation Ecology. Appleton-Century-Crofts.

5. Dasman, R.F. 1968. Environmental conservation. John Wiley and Sons.

6. IUCN Plant Red Data book. IUCN, London.

7. Misra, R. 1968. Ecology Workbook. Oxford-IBH Publishing Co.

8. Nayar, M.P. & Sastry, A.R.K. 1987, 1989, 1990, Red Data Book of Indian Plants. 3 VoIs. Botanical Survey of India.

9. Odum, E.P. 1976. Fundamentals of Ecology. W. B. Sanders.

10. Odum, E.P. 1983. Basic Ecology. W.B. Saunders.

11. Osborne P.L. 2012. Tropical Ecosystems and Ecological Concepts, (II Edn). Cambridge University Press

12. Puri, G. 1983. Indian Forest Ecology. Oxford-IBH Publishing Co.

13. UNESCO-Ecological Guidelines for tropical costal developments.

14. Wilson E.O. 1988. Biodiversity. The National Academic Press.

15. Wilson E.O. 1999. The diversity of life. W.W. Norton and Company.

Module 2- FOREST BOTANY (9 Hrs)

a. Definition of forests. Different types of Forest in the world and India.

b. Tree architecture - Definition, Types, Factors influencing tree architecture.

c. Major and minor forest products with special reference to Kerala. Forest based industries in Kerala.

Practicals

1. Collection of 5 Minor forest products in Kerala.
2. Construction of a map showing Forest types of India.

References:

1. Agarwal A.P. 1988: Forests in India, Oxford and IBH.

2. Champion S.G. & Seth, S.K. 1968. A Revised Survey of the Forest of India. Manager of Publ, Newdelhi.

3. Gregory G.R. 1971. Forest products production, trade and consumption, quantity and value of raw materials, requirements Ford foundation, New Delhi

4. Puri G.S. Indian Forest Ecology, Vol I and II, Oxford and IBH

Module – 3: PHYTOGEOGRAPHY (18 Hrs)

a. **Basics in Phytogeography(5 Hrs)**: Definition of Phytogeography; Plant distribution - Principles governing plant distribution, Factors affecting plant distribution, Theories on distribution and different types of distribution of vegetations on the earth. Continuous distribution - cosmopolitan, circumpolar, circumboreal or circum-austral, pantropical; Discontinuous distribution. Endemic distribution - Neo and paleo endemism. Factors influencing plant distribution; Migration of floras, and Evolution of floras.

b. **Major theories in Phytogeography (5 Hrs)**: Theory of land bridge, theory of continental drift, theory of polar oscillations or Shifting of poles, glaciations. Centers of origin and diversity of plants. Methods of dispersal, migrations and isolation; Theory of area and theory of tolerance. Age and area hypothesis.

c. **Floristic regions of the world (3 Hrs)**: Vegetation Zones in relation to latitudes and altitudes; a brief account of the phytochoria of the Indian subcontinent - climate, vegetation and botanical zones of India.

d. **Remote Sensing & GIS (5 Hrs)**: Definition, data acquisition techniques and various tools used for remote sensing. GIS: definition, fundamental concepts and components of GIS; developments and future trends in GIS. Applications of remote sensing and GIS. Geospatial variability and geotagging.

Practicals

1. Interpretation of maps, charts and Landsat imageries pertaining to the vegetation distribution and continental drift.

2. Collection of a remote sensing map of Kerala along with its interpretation.

References:

1. Avise, J.C. 2000. Phylogeography. The history and formation of species. Harvard University Press.

2. Brown, J.H. & M. V. Lomolino 1998. Biogeography. 2nd Edition. Sinauer Associates, Inc.

3. Cox, C.B., Healey, I.N. & Moore, P.D. 1976. Biogeography. An ecological and evolutionary approach. 2nd Edition. Blackwell Scientific Publications.

4. Emery W. & Camps A. 2017. Introduction to satellite remote sensing. Elsevier.

5. Mac Donald, G. 2003. Biogeography: Introduction to Space, Time and Life. John Wiley & Sons, Inc.

6. Schowengerdt R. 2012. Remote Sensing (II Edn). Academic Press.

7. Simmons, I.G. 1979. Biogeography: Natural and Cultural. Edward Arnold Ltd.

SEMESTER II

PSB2C06: GENETICS, PLANT BREEDING AND BIOSTATISTICS

Module – 1 GENETICS (36 Hrs)

a. **Basic Genetics (8 Hrs)**: History of Genetics; Concept of genes.

Mendelism - critical evaluation on Mendel's work and Mendelian Principles based on recent advances in genetics.

Chromosomal theory of inheritance and its modifications by the concept of Jumping genes, Pleiotropic genes and advances in Molecular Genetics.

Model organisms in Genetics - *Arabidopsis thaliana*, *Neurospora crassa*, *Escherichia coli*, *Drosophila melanogaster* and *Caenorhabditis elegans* (brief study).

b. **Plasmagenes (3 Hrs):** Cytoplasmic inheritance - chloroplast gene, *Mirabilis jalapa* and *Zea mays* and mitochondrial genes - petite, cytoplasmic male sterility in plants, maternal effect in inheritance in *Limnaea peregra.*

c. **Quantitative genetics (2 Hrs):** inheritance of quantitative traits, corolla length in *Nicotiana*, cob length in *Zea mays*, Multiple factors - continuous variation - continuous and threshold traits - QTL- Heritability- transgressive variation.

d. **Linkage and Crossing over (3 Hrs):** Bateson's concept, Stern's hypothesis, Creighton and McClintock's experiments, single cross over, multiple cross over, two-point cross, three-point cross, map distances, gene order, interference and co-efficient of coincidence. Haploid mapping (*Neurospora*), Mapping in bacteria and bacteriophages.

e. **Genetics of sex determination (2 Hrs):** XY, XX, XO, ZW, Dosage compensation, Barr body and Lyon's Hypothesis. Sex linkage - sex linked, sex influenced and sex limited characters; sex linked lethal mutations.

f. **Behavioural genetic**s (**2 Hrs**): Genetics of biorhythms - genetics of mammalian clock - genetics of behavior.

g. **Human genetics (8 Hrs)**: Inheritance of traits in humans; pedigree analysis, determination of human genetic diseases by pedigree analysis (ABO Locus), genetic mapping in human pedigrees. Autosomal recessive and dominant diseases: Sickle cell anemia, Huntington's chorea, familial hypercholesterolemia; inborn errors of Metabolism in Man – Phenylketonuria, Alkaptonuria, Albinism, Tyrosinosis, Goitrous Cretinism. Concept of eugenics, euphenics and euthenics.

h. **Genetic basis of cancer (2 Hrs):** Proto-oncogenes, oncogenes, conversion of proto-oncogenes to oncogenes. Tumor suppressor genes – functions, role of p53. Viral oncogenes.

i. **Population Genetics (6 Hrs)**: Systems of mating and their genetic effects. Genetic structure of populations and its change - Hardy–Weinberg equilibrium – Sewall Wright effect. Factors that alter allelic frequencies: (i) mutation (ii) genetic drift - bottle neck effect and founder effect (iii) migration (iv) selection (v) nonrandom mating; inbreeding coefficient.

Practicals

1. Workout problems related to linkage, crossing over and gene mapping, human pedigree analysis, cytoplasmic inheritance, multiple alleles and quantitative inheritance.

2. Work out problems in population genetics - gene and genotype frequency, Hardy-Weinberg equilibrium.

References:

1. Alberts, B. *et al*. 2007. Molecular Biology of the Cell. Taylor & Francis Inc.

2. Allison, L. 2007. Fundamental Molecular Biology. Blackwell Publishing Co.
3. Brooker R. J. Genetics: Analysis and Principles Addison Wesley Longman Inc.
4. Carroll, S. 2004. From DNA to Diversity. Blackwell Publishing Co.
5. Dabholkar A.R. Elements of Biometrical Genetics. Concept Publishing Company.
6. De Robertis, E.D.P. & De Robertis, E.M.F. 1987. Cell and Molecular Biology. Lea & Febiger.
7. Frankel O.H. & Bennet E. Genetic Resources in Plants. Blackwell.
8. Glick, B.R. & Thompson, J.E. 1993. Methods in Plant Molecular Biology and Biotechnology, Promega.
9. Griffiths A.J.F., Gelbbart W. M., Lewontin R.C. & Miller J.H. Modern Genetic Analysis. WH Freeman & Company.
10. Hartl D.L. & Jones E.W. 2007. Genetics – Analysis of Genes and Genomes, 7th edition, Jones and Barlett publishers.
11. Hartwell L.H., Hood L., Goldberg M.L., Reynolds A.E., Silver L.M. & Veres R.C. 2006. Genetics – From Genes to Genomes, 3rd edition, McGraw Hill.
12. Hedrick P. W. Genetics of Populations. Jones and Bartlett Publishers.
13. Hotter P. Text book of Genetics. Ivy Publishing House.
14. Karp, G. 2004. Cell and Molecular Biology: Concepts and experiments. 4th Edition. Wiley.
15. Kowles R. Solving Problems in Genetics. Springer.
16. Lewin B. 2008. Genes IX, Jones and Barlett Publishers. Singh RJ, 2002. Plant Cytogenetics, 2nd edition, CRC Press.
17. Sambamurthy A.V.S.S. Genetics. Narosa Publishing House.
18. Satpathy G.C. Genetics. Kalpaz Publications.
19. Scicchitano, D. 1998. Molecular Cell Biology W. H. Freeman & Co.
20. Strickberger M.W. 2008. Genetics, 3rd Edition, Pearson (Prentice Hall).
21. Turner, B.M. 2002. Chromatin and Gene Regulation. Blackwell Publishing Co.
22. Weising K., Nybom H., Wolff K. & Kahl G. 2005. DNA Fingerprinting in Plants: Principles, Methods and Applications, 2nd ed. Taylor and Francis Group, Boca Raton, FL.

Module – 2: PLANT BREEDING (18 Hrs)

a. **Basic Plant Breeding (4 Hrs)**: Objectives of Plant breeding, Floral Biology in relation to selfing and crossing techniques. Biological foundations of Plant breeding - Role of heredity and environment in character expression - Systems of reproduction in plants - Mating systems in sexually reproduced plants. Conventional methods of plant breeding

- Domestication of Plants
- Plant introduction: Types and procedures. National and international agencies for plant introduction. Certification, quarantine and Acclimatization
- Plant propagation - sexual, pseudosexual and asexual methods - special methods of plant propagation- micropropagation.
- Selection: principles, genetic basis and methods. Mass selection, Pureline selection and Clonal selection

b. **Conventional hybridization (2 Hrs)**: objectives, principle and methods of hybridization. Interspecific, intraspecific and distant hybridisation. Selection of Hybrids by Bulk method and

Pedigree method.

c. **Sources of plant germplasm (2 Hrs)**. Centres of genetic diversity. Concepts of de-Candolle and Vavilov, Primary, secondary and microcenters. Preservation and utilization of germplasm, Gene banks, NBPGR, International exchanges of germplasm.

d. **Methods of Crop improvement (2 Hrs)** in vegetatively propagating plants, sexually reproducing with unisexual and bisexual, autogamic and heterogamic plants.

e. **Back-cross breeding (2 Hrs)**: Theory and procedure for transferring various types of characters. Inbreeding consequences. Heterosis theories – genetic and physiologic basis – Applications in plant breeding – steps in the production of single cross, double cross, three way cross and synthetic cross.

f. **Genetics and Plant Breeding (4 Hrs)**: Genetics of Incompatibility and Sterility - male sterility, somatoplastic sterility - cytoplasmic and genetic sterility. Methods to overcome incompatibility. Genetic erosion – causes threatened species. Plant genetic conservation – (*in situ* and *ex situ*).

- Polyploidy breeding induction of autopolyploidy and allopolyploidy, role of chromosome manipulation – chromosome addition and substitution lines achievements.
- Mutation breeding: Situations suitable for mutation breeding. Materials needed for treatment. Physical and chemical mutagens. Handling of mutants. Evaluation of mutants in M1, M2 and M3 generations.

g. **Major achievements in Plant Breeding (2 Hrs)** - through inbreeding, back cross breeding, polyploidy breeding and mutation breeding. Resistance breeding for special purposes: Principles, Procedure and Achievements in breeding for pest, disease and stress resistance.

Practicals

1. Budding (T Budding, Patch Budding), Layering (Air and Serpentine) and Grafting (Whip and Crown).
2. Report of Breeding between any two varieties of one garden/crop plant with digital documentation.

References:

1. Chopra V. L. 2012. Plant Breeding theory and Practice, Oxford and IBH Publishing Company Pvt Ltd
2. Acquaah G. 2007. Principles of Plant Genetics and Breeding, Blackwell Publishing Ltd. USA.
3. Allard R.W. 1999. Principles of Plant Breeding (2nd Edition), John Wiley and Sons.
4. Chahal G.S. & Gosal S.S. 2002 Principles and Procedures of Plant Breeding. Narosa Publishing House.
5. Gupta S.K. 2005. Practical Plant Breeding. Agrobios.
6. Hayward M.D., Bosemark N.O. & Romagosa I. (Editors), 1993. Plant Breeding - Principles and prospects. Chapman and Hall.
7. Jain H.K. & Kharkwal M.C. Plant Breeding. Narosa Publishing House.
8. Khan M.A. Plant Breeding. Biotech Books.
9. Roy D. 2008. Plant Breeding - Analysis and Exploitation of Variation. Narosa Publishing House.
10. Sharma J.R., 1994. Plant Breeding. Tata McGraw Hill.
11. Sharma, A.K. & Sharma, R. 2014. Crop improvement and Mutation Breeding, Scientific Publisher.

12. Smartt J. & Simmonds N.W. 1995. Evolution of Crop Plants (2nd Edition) Longman.

Module – 3 BIOSTATISTICS (27 Hrs)

a. **Basics in Biostatistics (7 Hrs)**: Introduction and scope of biostatistics. Measures of central tendencies - mean, median and mode. Skewness and kurtosis. Measures of variations - range, quartile deviation, mean deviation, variance and standard deviation. Standard error and Coefficient of variation.

b. **Advanced Biostatistics (7 Hrs)**: Tests of significance- z, t and χ^2 tests. Analysis of variance (ANOVA) - one way, two way and multiple. Correlation (Pearson's correlation coefficient, Spearman's rho) and Regression (Linear regression, Least Square method) analysis; Factor and cluster analysis. Introduction to R programming and SPSS.

c. **Study Designs and Experimental designs in Biology (7 Hrs)**: Classification of study design, Observational studies and Experimental studies (uncontrolled studies, trials with external controls, crossover studies, trials with self controls, trials with independent concurrent controls). Experimental Designs: Randomized Block Design, Split plot design and Latin Square

d. **Sampling, Data Collection and Data Tabulation methods (4 Hrs)**: Sampling: Reasons for sampling, methods of sampling, SRS, Systematic, Stratified, Cluster, NPS. Methods of data collection - primary and secondary data - census and sampling methods. Tabulation and presentation of numerical data - diagrammatic and graphical presentation. Graphs, Histograms, Box and Whisker plots, Frequency polygon, Scatter Plots.

e. **Biometrical genetics (2 Hrs)** - probability and genetics - prediction of genetic behavior - statistical tools in genetic analysis.

Practicals

1. Diagrammatic and graphic representation of data using programmes like MS Excel, Open Office Calc or Statistica.
2. Analysis of numerical data for mean, median, mode, variance, standard deviation, standard error and coefficient of variation.
3. Analysis of variance between data from different samples using MS Excel one way, two way and multiple.
4. Calculation of correlation coefficient between groups of data and calculation of critical difference.
5. Demonstration of statistical analysis using the softwares - R Programming and SPSS, using a given data set.

References:

1. Bailey, N. T. J. 2012. Statistical Methods in Biology, Cambridge University Press.
2. Kulas J. T. 2008. SPSS Essential: Managing and Analyzing Social Science Data. John Wiley & Sons, New York.
3. Pagano M. & Gauvreau K. 2007. Principles of Biostatistics. Thomson India Edition, New Delhi. 5. Randal
4. Panse V.G. & Sukhatme, P.V. 1967. Statistical Methods for Agricultural Workers. ICAR.
5. Rangaswamy R. A. 2009. Text Book of Agricultural Statistics. New Age International Publishers.
6. Rastogi V. B. 2015. Biostatistics, Medtech.
7. Rosenkrantz W. A. 2009. Introduction to Probability and Statistics for Science, Engineering and

Finance. CRC Press.

8. Sharma J. R. 2008. Statistical and biometrical techniques in Plant Breeding. New Age International Publishers.
9. Wickham, H. & Grolemund, G. 2016. R for Data Science. O'Reilly Media.

SEMESTER II

PSB2C07: EVOLUTION, MICROTECHNIQUE AND INSTRUMENTATION

Module 1: EVOLUTION (18 Hrs)

a. **Introduction (2 Hrs)**: Evolution of biomes. Mixing process, intercontinental connections. Climatic zonation, dispersal opportunities, dispersal availability, sub-climax and climax dispersal. Phylogeny and age of biomes: Interwoven biome phylogeny and biome extension and resurrection.

b. **Origin and evolution of life** (**2 Hrs**): General outline on Classical and synthetic hypotheses and theories of evolution. Chemical evolution - Oparin-Haldane theory, Miller Urey experiment, Path of Chemical evolution. Biological Evolution - Coacervate theory, origin and evolution prokaryotic and eukaryotic cells, Endosymbiotic theory.

c. **Paleobotany and geological time scale (2 Hrs)**: Geological time scale, Geological evidences of evolution: The fossil record - Types of Fossils and Mechanism of fossilization. Geological fundamentals. Phylogeny and the fossil record. Evolutionary trends. Rates of evolution.

d. **Evidences for evolution (2 Hrs):** Morphology, comparative anatomy, embryology, physiology, biochemistry, paleontology and biogeography. Micro and macro-evolution and punctuated equilibrium.

e. **Natural selection (2 Hrs):** Natural selection and adaptation. Nature of natural selection, limiting factors, origin of races and species, Kin's selection and Hamilton's Rule. Rate of evolutionary change: Internal and external factors. Significance of genetic drift in natural selection.

f. **Mutation as an evolutionary force (2 Hrs):** Mutation and genetic divergence. Evolutionary significance of mutations. Genetic assimilations (Baldwin effect). Genetic homoeostasis. Mutation for natural selection. Eugenics and euthenics.

g. **Speciation (3 Hrs):** Species concept; morphological species, biological species and evolutionary species. Mode of speciation – allopatric, sympatric and parapatric. Types of speciation - phyletic and true-speciation. Hybridization (Double cross hybrid of field Corn); Rate of hybridization and introgression in evolution of species. Reproductive isolation: Pre-zygotic and post-zygotic isolation.

h. **Co-evolution (3 Hrs):** Symbiosis. Plant-animal Co-evolution; mutualism, commensalism. Protective - colouration and shape. Mimicry: Batesian and Mullerian mimicry. Molecular tools in phylogeny.

Practicals:

1. Demonstration of Evolutionary Principles through computer exercises.
2. Biological diversity - Interspecific variation and intraspecific variation: Intraspecific variation in size and shape of leaves.
3. Phylogenetic trees, reading and using trees.
4. Floral evolution and MADS-box. Biological diversity - Intraspecific variation: Phenotypic morphological variation.
5. Microevolution: Phenotypic variation and the environment: Intraspecific variation (e.g., stomatal size and density in sun and shade leaves).
6. Macroevolution: Inferring Phylogenies, comparative analyses. Field, laboratory and computer exercises.

References:

1. Agarwal S.K., A.G. Nautiyal & A. Chibbar 2019. Biology - the science of life and Diversity.

MedTech, Scientific International, New Delhi.

2. Barton, N.H. *et al*. 2007. Evolution. Cold Spring Harbor Laboratory Press.
3. David Briggs & Stuart Max Walters 1997. Plant Variation and Evolution, Cambridge University Press.
4. Futuyma, J.D. 1998. Evolutionary Biology (3rd Edition), Sinauer Associates.
5. Kardong, K.V. 2007. An introduction to biological evolution. McGraw-Hill.
6. Ridley, M. 2004. Evolution. Oxford University Press.
7. Roderic D.M. Page, Edward C. Holmes (1998). Molecular Evolution: A Phylogenetic Approach, Blackwell.
8. Scott R, Freeman & Jon C. Herron 2003. Evolutionary Analysis, Prentice Hall.
9. Starr C. 2006. Biology Concepts and Applications 6 edition , Thomson Brookes/Cole.

Module 2: MICROTECHNIQUE (18 Hrs)

Killing and Fixing (3 Hrs) Principles and techniques of killing and fixing; properties of reagents, fixation images; properties and composition of important fixatives - Carnoy's Fluid, FAA, FPA, Chrome acetic acid fluids, Zirkle-Erliki fluid.

Dehydration, Clearing, Embedding and Sectioning (5 Hrs) (a) Dehydration: Principles of dehydration, properties and uses of important dehydrating and clearing agents - alcohols, acetone, xylol, glycerol, chloroform, dioxan. (b) Dehydration Methods: (i) Tertiary-butyl alcohol method. (ii) Alcohol-xylol method. (c) Embedding: Paraffin embedding. (d) Sectioning: Free hand sections – prospects and problems; sectioning in rotary microtome, sledge microtome and cryotome.

Staining (5 Hrs) (a) Principles of staining; classification of stains, protocol for preparation of: (i) Natural stains - Haematoxylin and Carmine (ii) Coal tar dyes – Fast green, Orange G, Safranine, Crystal violet, Cotton Blue and Oil Red O. (b) Techniques of staining: (i) Single staining; Staining with Safranine or crystal violet. Double staining; Safranine-Fast green method, Safranine-Crystal violet method. Triple staining; Safranine-Crystal Violet-Orange G method. (c) Histochemical localization of starch, lipid and lignin.

Mounting techniques (5 Hrs) (a) Mounting: Techniques, common mounting media used - DPX, Canada balsam, Glycerin jelly and Lacto phenol (b) Whole mounts: Principles and techniques of whole mounting, TBA/Hygrobutol method, Glycerine xylol method. Staining of whole mount materials (haematoxylin, fast green or Safranine-fast green combination). Significance of whole mounts. (c) Techniques of smear, squash and maceration (d) Cleaning, labeling and storage of slides.

Practicals

1. Students are expected to be thorough with the following techniques. (a) Preparation of semi-permanent slides. (b) Preparation of permanent slides. (c) Preparation of whole mounts. (d) Maceration. (e) Preparation of fixatives (FAA, Carnoy's fluid). (f) Preparation of dehydration series (Alcohol, Acetone, TBA). (g) Preparation of paraffin blocks. (h) Preparation of serial sections.
2. Candidates should prepare and submit 10 permanent slides in which the following categories should be included: (a) Free hand sections (single/double stained). (b) Serial sections (single/double stained). (c) whole mounts.

References

1. Johanson D.A. 1940. Plant microtechnique. McGraw Hill co.

2. John E. Sass 1967. Botanical Microtechnique. Oxford IBH Publ. Company.

3. Gray 1964. Handbook of Basic Microtechnique. McGraw Hill co.

4. Prasad M.K. & M. Krishna Prasad 1983. Outlines of Microtechnique. Emkay Publications.

5. Geoffrey A. Meek 1976. Practical electron microscopy. John Willey and sons.

6. Krishnamurthy K.V. 1987. Methods in Plant Histochemistry. S. Viswanathan printers, Anand book Depot, Madras.

7. Toji Thomas 2005. Essentials of botanical microtechnique (II Edn). Apex infotech publishing company.

Module 3: INSTRUMENTATION (27 Hrs)

- **Introduction to Microscopy** (**5 Hrs**) Parts of microscope, principles of microscopy. Types of microscopes - simple and compound; stereo microscope, phase contrast microscope, fluorescence microscope. Electron microscopy (TEM, SEM, ESEM, Cryo EM (brief study). Micrometry. Photomicrography, Camera Lucida.
- **Basic principles, parts, types and applications of instruments and/or methods** (**10 Hrs**):
  - Centrifugation**:** Rotors, Bench top, Low speed, High speed, Cooling and Ultracentrifuge**.**
  - Spectroscopy**:** Principle and applications of UV, Visible, IR, Raman, Spectroflurometry, Mass, AAS, NMR, ESR, MS and MALDI-TOF**.**
  - Chromatography: Types of Chromatography: Paper, TLC, Column chromatography, ion exchange chromatography, GCMS, HPLC, HPTLC and LCMS.
  - Electrophoresis: Agarose gel Electrophoresis, SDS PAGE, Pulse Field Gel Electrophoresis.
- **Methods for Nucleic Acid Study (7 Hrs)**:
  - Nucleic Acid Sequencing**:** Maxam Gilbert method, Sanger method.
  - Polymerase Chain Reaction**:** Principle, Procedure, Variations and Applications.
  - Detecting DNA Polymorphism: Principle, methods and applications of RFLP, AFLP, RAPD.
  - Nucleic Acid Hybridization**:** Principle of Hybridization, Blotting Techniques (Southern blotting, Northern blotting, South-Western blotting, Western blotting).
- **Immunological techniques (2 Hrs)**: Antigen-Antibody interaction, immunofluorescence, Immunodiffusion, Immunoprecipitation, Immunoelectrophoresis, RIA, ELISA.
- **Biophysical methods (3 Hrs)**:
  - Analysis of biopolymer structure:-X ray diffraction, fluorescence.
  - Flow cytometry. Cryobiology - Lyophilisation and its applications.
  - Use of Radioisotopes**:** GM counting, Scintillation counting, Autoradiography.

Practicals

1. Micrometry.
2. Electrical conductivity and pH measurements.
3. Preparation of Buffers: Phosphate, Carbonate and Tris HCl.
4. Quantitative estimation of chlorophyll content using spectrophotometer.
5. Absorption spectra of BSA/DNA and determination of absorption maxima.
6. Gel filtration.
7. Use of Camera Lucida.
8. Separation of leaf pigments by paper chromatography and TLC.

9. Immunodiffusion technique for testing of antigens and antibodies.
10. Rocket immunoelectrophoresis.
11. Separation of isozymes by native polyacrylamide gel electrophoresis.
12. Histochemical localization of Polysachharides, Total proteins, DNA.

References:

1. Bajpai P.K. 2010. Biological Instrumentation and Methodology: (Tools and Techniques). S. Chand & Co.
2. Boyer R.F. 2000. Modern experimental Biology. Prentice Hall.
3. Browning D.R. Spectroscopy. McGraw-Hill.
4. Chatwal, G.R. & Anand, S.K. 2011. Instrumental Methods of Chemical Analysis. Himalaya Publishing House.
5. Freifelder, D. 1982. Physical Biochemistry. W. H. Freeman.
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SEMESTER II

PSB2C08: MICROBIAL AND PLANT BIOTECHNOLOGY

Module – 1 MICROBIAL BIOTECHNOLOGY (14 Hrs)

a. Genetic Engineering: Tools used in genetic engineering (2 Hrs):

i. Cloning vectors (plasmid and bacteriophage vectors, cosmids BAC and YACs.

ii. Enzyme (Restriction endonucleases, exonucleases, polymerases, reverse transcriptase, alkaline phosphatase, polynucleotide kinase, Ligases, terminal transferases, topoisomerase, DNA methylase)

iii. DNA cloning, preparation of plasmid DNA, Restriction and electrophoresis, ligation, transformation and analysis of recombinants.

b. Techniques of Genetic Engineering (3 Hrs)**:** Principles and methods of Genetic Engineering, Gene libraries and cDNA libraries. Restriction mapping.

c. Microbial inoculants (2 Hrs): bacterial inoculants - Rhizobacterial inoculants (Nitrogen-fixing bacteria and Phosphate-solubilising bacteria), Fungal inoculants (mycorrhizae and endophytes), Composite inoculants.

d. Microbial biotechnology (5 Hrs): Mode of operation of a bioprocess – basic concepts of batch, fed batch and continuous operation of a bioprocess. Basic design and construction of various types of bioreactors used in bioprocesses. Commercial production of metabolites using bioreactors. Submerged and solid state fermentation. Microbes in production of enzymes, antibiotics, biopolymers, bioethanol, organic acids, SCP. Ethics and Safety in bioetchnology.

e. CRISPR technology (2 Hrs): Methods and applications.

Module – 2 GENETIC ENGINEERING OF PLANTS (10 Hrs)

a. Plant Genetic Engineering (3 Hrs)**:** Methods of direct and indirect gene transfer in plants, *Agrobacterium*, Ti and Ri plasmids, application of genetic engineering, transgenic plants for insect, fungal and bacterial disease resistance, lignin, modification, abiotic stress tolerance, production of useful products.

b. *Agrobacterium* and Plant Genetic Engineering (4 Hrs): *Agrobacterium*-mediated gene transfer and cloning. Types of plant vectors and their use in gene manipulation. Selectable markers for plant transformation, molecular mechanism of T-DNA transfer - based on vector and Ti plasmid; protocol for *Agrobacterium*-mediated genetic transformation of plants; its success in monocots and dicots with specific examples.

c. GMMs, GMOs and GMPs (3 Hrs): Major successful organisms and their production details-pest resistant, stress resistant, nutrient enhanced varieties. Pros and cons of GMOs in biosafety, IPR and other related aspects.

Module – 3 PLANT TISSUE CULTURE (7 Hrs)

a. Plant Tissue Culture (2 Hrs): General technique, Laboratory and equipments, aseptic techniques, nutrient medium. Morphogenesis, Plant regeneration, Callus, induction, transfer – subcultures, growth kinetics, cell suspension, somatic embryogenesis, advantages, synthetic seeds - application.

b. *In vitro* Production (2 Hrs): Micropropagation, cloning, various stages, applications, pathogen indexing, meristem culture, advantages, Haploids - androgenesis, pathways, factors affecting, advantages – applications, gynogenesis, Phytochemicals, large scale cultures, bioreactors, improvement – elicitors, hairy root cultures, biotransformation and applications.

c. Plant Improvement (1 Hr)**:** Somatic hybridization, protoplast isolation, culture, fusion, advantages. Somaclonal variation, origin, advantages.

d. Complementary Techniques (2 Hrs): Germplasm conservation, slow growth, cryopreservation (freezing – thawing), cryoprotectants and applications. Distant hybridization, *in vitro* pollination/ fertilization, embryo culture, embryo rescue, applications.

Module – 4: NANOBIOTECHNOLOGY (5 Hrs)

a. History, development and branches of nanobiotechnology. Nanomaterials in nature. Nanomaterials used in biotechnology - nanoparticles, quantum dots, nanotubes and nanowires. Method of biological synthesis of 'Zn' and 'Ag' nanoparticles – plant extract, bacteria and fungi.

b. Biosensors; different types - molecular recognition elements, transducing elements; applications of nanobiosensors. Miniaturized devices: types and applications, lab on a chip concept.

c. Nanobiotechnological applications in health care and disease diagnosis and treatment; applications in environment and food - detection and mitigation. Bioethics and Biosafety of Nanobioetchnology.

Practicals

1. Preparation of culture medium (MS, N & N, SH, B5 and Whites), sterilization and inoculation methods.

2. Shoot multiplication, Callus culture and organogenesis of important crops/medicinal plants/ornamentals.

3. Demonstration of Agarose gel electrohoresis.

4. Encapsulation of seeds/embryos in calcium alginate.

5. Estimation of DNA concentration by Spectrophotometric method.

6. Estimation of RNA concentration by Spectrophotometric method.

References:

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14. Silva, G.A. & Parpura, V. (Eds.) 2012. Nanotechnology in Biology and Medicine: Methods, Devices, and Applications. Springer Verlag, NY.

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SEMESTER III

PSB3C09: PLANT PHYSIOLOGY AND BIOCHEMISTRY

Module – 1 PLANT PHYSIOLOGY (54 Hrs)

a. Introduction (1 Hr): History and significance of Plant Physiology - Contribution of Indian Plant Physiologists - J C Bose and V S Ramadas.

b. Absorption and translocation of water (4 Hrs): apoplastic, symplastic and trans-membrane pathways. Mechanism and theories of xylem transport, passive and active transport. Aquaporins. Water pathway in the leaf – driving force of transpiration, leaf anatomy for regulating transpiration. Cavitation and Embolism. Soil-plant-atmosphere continuum. Stomatal biology – light dependent stomatal opening.

c. Absorption of minerals (6 Hrs): Soil characters influencing nutrient availability – size and charge of soil particles, soil pH, interaction between roots and microbes. Mechanism of entry of minerals into roots. Transport of ions, solutes and macromolecules: Electrical properties of membranes, Membrane potential. Transport across cell membranes: Passive – diffusion, facilitated diffusion, membrane channels; plasmodesmata, porins, ion channels – gated channels, Voltage dependent K+ channels, voltage gated channels, Calcium channels, Vacuolar malate channels. ATPase activity and electrogenic pumps. ABC transporters. Patch clamp studies. Active transport and electrochemical potential gradients.

d. Photosynthesis (10 Hrs): Light harvesting complexes: PS I, PS II; Structure and composition of reaction centers. Basic principles of light absorption, excitation energy transfer, mechanism of electron transport, photo-oxidation of water, proton electrochemical potential – photophosphorylation. Structure and function of Rubisco, CO2 fixation - C3, C4 and CAM metabolism. Physiological and environmental consideration of photosynthesis. CO2 concentrating mechanisms – algal and cyanobacterial pumps, Photosynthetic quantum yield and energy conversion efficiency. Transport of photoassimilates – phloem loading and unloading, Starch and sucrose synthesis. Allocation and partitioning mechanism of phloem translocation – pressure flow of plasmodesmata in symplastic transport. Thylakoid ET inhibitors, Photoinhibition and its tolerance mechanism.

e. Respiration (8 Hrs): Glycolytic reactions: Pyruvate entry into mitochondria and citric acid cycle. Electron transfer system and ATP synthesis. Transporters involved in exchange of substrates and products, ATP synthesis, Cyanide resistant pathway, Rotenone-insensitive pathway in plants and Pentose Phosphate Pathway (PPP). Interaction between mitochondrial and other cellular components. Metabolites and specific transporters. Detailed structure of F1 and Fo subunits, binding change mechanism of ATP synthesis. Comparison of mitochondrial and chloroplast ATP synthesis.

f. Nitrogen metabolism: (4 Hrs) N cycle. N fixation processes; Biological N fixation – structure of nitrogenase complex, reduction of N. Symbiotic N fixation – nodule formation, nodulin gene and nodulation genes, leghaemoglobin. Nitrate and ammonium assimilation. Assimilation of ammonia; pathways and enzymes - GS, GOGAT and GDH. Importance of phosphorus, iron, magnesium, calcium and potassium assimilation. Energetics of nutrient assimilation, molecular physiology of micronutrient acquisition. Transport of amides and ureides.

g. Growth, differentiation and development (8 hrs): Analysis of plant growth: production of cells, growth velocity profile. Cytological and biochemical events. Differentiation: secondary cell wall formations, multinet growth hypothesis of cell wall. Development: initiation and regulation of development, genes involved in the control of development, role of protein kinases. Types of development: flowering - floral induction, evocation and morphogenesis. Floral organ identity genes. Biochemical signaling: Theories of flowering. Control of

flowering - phytochrome, cryptochrome and biological clock. Factors affecting flowering: Photoperiodism and thermoperiodism. Fruit development and ripening: physiology of ripening - cell wall architecture and softening, enzymes involved in biochemical changes. Seed development: deposition of reserves during seed development, desiccation of seeds: hormones involved, desiccation tolerance. Classification of seeds, seed dormancy. Germination physiology: Imbibition, germination and reserve mobilization - metabolism of carbohydrates, lipids, proteins and phytins, physiology of seed dormancy.

h. Plant growth regulators (5 Hrs): auxins: biosynthesis, transport, physiological roles. Role in signal transduction pathways. Gibberellin: biosynthesis, physiological roles, signal transduction. Amylase activity in germinating seeds. Cytokinin: biosynthesis. biological role, morphogenesis in cultured tissues; mode of action. Ethylene: biosynthesis, physiological role, commercial uses, and mode of action. Abscisic acid: biosynthesis and metabolism, physiological effects, role in seed dormancy and senescence. Hormonal balance concept. Role of elicitors in growth regulation.

i. Photoreceptors (4 Hrs): Phytochromes - photochemical and biochemical properties, localisation in cells and tissues, phytochrome induced whole plant responses, Ecological functions. Mechanisms of phytochrome regulated differentiation. Signal transduction pathways, role in gene expression. Cryptochromes: blue light hormones photophysiology, effect on stem elongation, gene expression, stomatal opening, proton pumps, phototropism, role of carotenoids.

j. Senescence and programmed cell death (2 Hrs): Apoptosis and necrosis. Programmed cell death in relation to reproductive development, and stress response. Genes associated with senescence, metabolism during senescence.

k. Stress physiology (2 Hrs): Water deficit and drought resistance, heat stress and heat shock, chilling and frost, salinity stress, oxygen deficiency stress and heavy-metal pollution stress. Acclimation and adaptation mechanisms in plants.

Practicals

1. Preparation of molal, molar, normal and percentage solutions and their dilutions.
2. Determination of moisture content of plant materials.
3. Determination of osmotic potential by plasmolytic method.
4. Analysis of Phosphorus in plant tissues.
5. Separation of plant pigments by paper chromatography.
6. Quantitative estimation of chlorophyll content using spectrophotometry.
7. Measurement of Photosynthesis - Hill Reaction.
8. Measurement of Light Intensity and Light Transmission Ratio.
9. Measurement of growth rate using various parameters.
10. Demonstration of Amylase activity and gibberellic acid effect in germinating cereal seeds.
11. Regulation of Seedling Growth by Plant Hormones.

References:

1. Ainsworth C. 2006. Flowering and its Manipulation, Annual Plant Reviews, Vol. 20. Blackwell Publishing, Oxford, U.K.
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Press.

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Module – 2 BIOCHEMISTRY(27 Hrs)

- Introduction (3 Hrs): History, Significance of Biochemistry and Biomolecules. Indian contributors - Ramachandran, Bhargawa. Acid and Bases, ionisation of water, dissociation of acids, Henderson-Hasselbalch equation, pKa. Buffers - Common buffers (acetate, citrate and phosphate), buffer action, buffer capacity.
- Carbohydrate(6 Hrs): mono-, di-, oligo- and polysaccharides, linear and ring structures, homo- and heteroglycans, artificial sweeteners, structure and function of major homo- and heteropolysaccharides, metabolism of starch, cellulose and glycogen. glycoproteins and proteoglycans, biosynthesis of peptidoglycan, metabolic mill.
- Amino acids and proteins (5 Hrs): amino acids – classification, properties, optical activity, unusual aminoacids, classification and conformation proteins, Ramachandran plot. Structure, function, mechanism and allosteric regulation of haemoglobin, abnormal haemoglobin, structure and function of leghaemoblobin, Brief account on the biosynthesis and degradation of protein.
- Enzymology (5 Hrs) – structure, function and classification of enzymes, coenzymes, substrate specificity, regulation of enzyme activity, enzyme kinetics, Michaelis-Menten constant, Lineweaver-Burk plot. Active sites, inhibitors, allosteric enzymes, kinetics, negative and positive co-operativity, multienzyme, isoenzymes, ribozyme, abzyme, detailed study of FAS

and Rubisco.

- Lipids (5 hrs) – classification, brief account on compound and derived lipids with examples, classification of fatty acids, biosynthesis of fatty acids (microbes, plants and animals), alpha, beta and omega oxidation of fatty acids, omega fatty acid and functional food, trans-fatty acids and their dangers, detailed study of coconut oil.
- Secondary metabolites (3 Hrs): Classification, biosynthesis and functions of terpenoids, alkaloids and phenolics.

Practicals

1. Preparation of standard solutions of BSA, Glucose and Catechol.
2. Detection of non-reducing sugar in the presence of reducing sugar.
3. Quantitative estimation of reducing sugar from plant tissue by any suitable method.
4. Extraction and estimation of starch from plant tissue by a suitable method.
5. Colorimetric estimation of protein by Biuret method and soluble proteins by Bradford method.
6. Colorimetric estimation of protein by Lowry *et al*. method.
7. Measurement of amylase/invertase/protease from any suitable plant/microbial source using suitable method.
8. Determination of Substrate saturation and Michaelis-Menten curve of any enzyme.
9. Paper chromatographic separation of sugars.
10. Isolation and quantification of plant lipids by dry and lipid methods.
11. Extraction and estimation of total phenols.

References:

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and Co.

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SEMESTER III

PSB3C10: ANGIOSPERM MORPHOLOGY AND SYSTEMATICS

Module – 1 ANGIOSPERM MORPHOLOGY (9 Hrs)

a. General concepts of morphology. The concept of primitive angiosperms and the current ideas of the origin of angiosperms with reference to their ancestors; origin and evolution of flower, the concept of primitive flower; co-evolution of flowers vis-a-vis pollinators.

b. Stamen evolution and evolution of androecium. – haplo-, obhaplo-, diplo- and obdiplostemounous condition.

c. Evolution of carpels: concepts of foliar origin of carpels, alternative concepts and approaches, gonophyll theory; evolution of ovary – poly and syncarpy – superior, semi-inferior and inferior ovary - appendicular and receptacular theories – evolution of placentation types.

d. Role of floral anatomy in interpreting the origin and evolution of flower and floral parts. Morphology of nectaries.

Practicals

1. Preparation of cleared whole mounts of floral parts to show vasculature.
2. Critically examine primitive flowers and their parts.
3. With the help of dissections and hand sections, examine:
   a. Transmitting tissue/canals in style and stigma.
   b. Different types of ovaries.
   c. Vasculature of androecium and gynoecium in special types of flowers.
   d. Different types of placentation.

References

1. Barnard C. 1901. The interpretation of Angiosperm flower. Aust. J. Sci. 24; 64-72.
2. Eames A.J. 1961. Morphology of Angiosperms. Macmillan Company.
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Module – 2 SYSTEMATICS (43 Hrs)

a. Systematics and Taxonomy (3 Hrs): Definitions, Comparison and Differentiation, Objectives and Scope of Taxonomy. Historical development of plant taxonomy in India with special reference to the contribution by William Roxburgh, Santapau and K. S. Manilal.

b. Historical development of theories and concepts of plant classification and classificatory systems (10 Hrs). Conceptual bases of the classifications of the following: Bentham & Hooker, Engler & Prantl, Hutchinson, Cronquist, Takhtajan and APG System. Modern trends in Plant Taxonomy: Biosystematics, Numerical Taxonomy (Taximetrics), Cladistics, Molecular Taxonomy.

c. Taxonomic structure (2 Hrs): Taxonomic hierarchy, taxonomic categories – supraspecific and intraspecific categories - subspecies, variety, forma; Concepts of species, genus and family.

d. Taxonomic characters (5 Hrs): Concept of character, character variations and their taxonomic implications. Sources of taxonomic characters: Morphology, Anatomy, Embryology, Palynology, Cytology, Phytochemistry, Molecular characters and DNA barcoding.

e. Practical identification of plants (7 Hrs): Different kinds of Identification keys, Construction of dichotomous keys – Indented and bracketed keys. Various kinds of Taxonomic literature: General indices, Floras, Revisions, Manuals, Icons, Monographs, Reviews, Periodicals and Journals; online data bases, eFlora. Usage of floras and brief account on Flora of the British India, Flora of the Presidency of Madras, *Hortus Malabaricus*. Important Floras of Kerala. Familiarization of technical terms associated with the following: habit, habitat; root, stem, leaf, inflorescence; bract and bracteoles; flowers; fruits and seeds.

f. Tools of Taxonomy (5 Hrs) Field study, herbarium and virtual herbarium, important botanical gardens; BSI; Herbaria - definition and techniques involved in the preparation of Herbarium. Management of Herbaria; Major Herbaria in India (CAL, MH, BSI) and the World (K, NY); Role of Herbaria in taxonomy. Floristic studies in India; Major centers of taxonomic and floristic studies in India; Organization and functions of the Botanical Survey of India

g. Botanical Gardens (2 Hrs): Role in taxonomy and biodiversity conservation. History and major Botanical gardens of India (Indian Botanical Garden, Calcutta; National Botanical Garden, Lucknow and JNTBGRI, Thiruvananthapuram) and World (Royal Botanical Garden, Kew; Kirstenbosch Botanical Garden, Cape town. South Africa).

h. Plant Nomenclature (5 Hrs): Brief History on the origin and development of nomenclature; detailed study of the major provisions of the International Code of Nomenclature (ICN) Effective and Valid Publication, Rule of Priority and its limitations, Typification, Different kinds of types, Author citation, Rejection and retention of names; double citation, basyonym, Conserved names; Nomenclature of hybrids; Nomenclature of cultivated plants. Common technical terms used in Plant nomenclature.

i. Problems in Evolutionary taxonomy (4 Hrs): Concept of primitive and advanced characters/groups, monophyly and polyphyly, paraphyly, parallelism and convergence, homology and analogy.

Practicals

1. During the course of this study, the student shall get familiar with the local flora.

2. The students should be able to describe angiosperms in technical terms, preparing scientific illustrations, constructing artificial keys and identify them based on Bentham and Hooker's system of classification. For this purpose, each student shall work out at least 2 members of each of the following families of angiosperms available in the area: Ranunculaceae, Menispermaceae, Annonaceae, Cruciferae, Polygalaceae, Caryophyllaceae, Tiliaceae, Rutaceae, Rhizophoraceae, Melastomataceae, Aizoaceae, Rubiaceae, Asteraceae, Oleaceae, Asclepiadaceae, Gentianaceae, Boraginaceae, Solanaceae, Scrophulariaceae, Pedaliaceae, Acanthaceae, Lamiaceae, Amaranthaceae, Loranthaceae, Euphorbiaceae, Urticaceae, Commelinaceae, Zingiberaceae, Araceae and Cyperaceae.

3. During the course of the study, each student shall undertake a field study tour for at least 3 days. Each one shall also collect plant specimens (belonging to any family) for herbarium preparation and shall submit at least forty herbaria along with the field book and report for evaluation during the course of their practical examination.

4. Preparation of technical descriptions and dichotomous/indented keys using locally available plants (any families).

5. Exercises in nomenclatural citations and solving nomenclatural problems.

References:

1. Cronquist, A. 1988. The evolution and classification of flowering plants. New York Botanical

Garden Press.

2. Dahlgren, R.M.T., Clifford, H.T. & Yeo, P.F. 1985. The Families of Monocotyledons. Springer-Verlag.

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SEMESTER III

PSB3C11: BASIC BIOINFORMATICS

Module – 1: BASIC INFORMATICS

a. Introduction to Computer: Definition, Salient features, limitations and capabilities of Computers. Evolution of Computers - generations of Computers. Types of Computers - based on size and purpose. Applications of computers in various fields

b. Major Computer components and peripherals – ALU, Memory Unit, Control Unit, motherboard, SMPS, Expansion Slots, Serial and Parallel ports, USB. Concept of Memory: Primary Memory – RAM, ROM, EPROM, PROM. Secondary Storage devices: - Magnetic disk, Magnetic tape, Floppy disk, Pendrive, DVD/CD ROM, Cache memory RAM, ROM, PROM, EPROM, Input and Output Devices.

c. Introduction to Operating Systems: Definition and Functions of O.S. Types of O.S. –Single user, Multi-user (Windows and Linux), Graphical User interface. Disk Operating System (DOS): DOS internal and external commands.

Module 2: NETWORKING OF COMPUTERS

a. Networking of Computers - Basic principles, tools and techniques used in Computer Networking- Hardwares in networking - Network Cables, Distributors, Routers, Internal Network Cards, External Network Cards. Softwares in networking - SDN framework. Major types of Network softwares.

b. Types of Computer networks - Internet and intranet.

c. Introduction to Internet: TPC/IP, WWW, FTP, registration with ISP, Internet connection wizard, URL, http, internet access methods: Dial-up, DSL, Cable, ISDN, Wi-Fi.

Module 3: BASICS IN BIOINFORMATICS

a. Bioinformatics: History, branches and significance of bioinformatics.

b. Types of Biological data - Biodiversity data, Molecular data - DNA, RNA and Protein sequences. Genomes and proteomes. Eukaryotic genome with special references to model organisms (Yeast, *Drosophila*, *Caenorhabditis elegans*, Rat and Mouse), human, plants such as *Arabidopsis thaliana* and Rice.

c. Bioinformatic Resources: NCBI, EBI, ExPASy, RCSB. Nucleotide sequence Databases: GenBank, EMBL, DDBJ; Protein sequences Databases: Swiss-Prot, TrEMBL, UniProt, UniProtKB, UniParc, UniRef, UniMES; Sequence motifs Databases: Prosite, ProDom, Pfam, InterPro, Gene Ontology; Sequence file formats: GenBank, FASTA, PIR, ALN/ClustalW2. Patent databases, TAIR, PDB, ATIDB, OMIM; Medical databases, KEGG, EST databases, Chemical Databases: ZINC, Pubchem, Chembl.

d. Fundamentals of computer programming, Common Languages in Bioinformatics - PERL. C++ and Python - Python Data Types, Python variables, Operators, Lists in Python, operations, methods, parameters, Iterators, Generators, Comprehensions and Expressions – Tuples, Python Dictionaries and Sets. Advanced Concepts in Python Programming – Files reading and writing, command line arguments, Exception handling, Modules and Packages, Control Statements and Regular Expression, string functions and methods, Using Databases in Python - Introduction to Biopython - Sequence objects - Database search using Biopython, Python for Data Analysis.

Module 4: BASICS IN SEQUENCE ANALYSIS

a. Various biomolecular sequences - DNA, RNA, Proteins and their significance and interrelationship.

b. Basic concept of sequence similarity, identity and homology, definition of homologous, paralogous, orthologous and xenologous sequences.

c. Various file format for Bio-molecular Sequences: GenBank, FASTA, GCG, MS, NBRF-PIR, ALN/ClustalW2**.**

d. Scoring matrices: Basic concept of scoring matrix, matrices for nucleic acid and protein sequences, PAM and BLOSOM series, principles based on which these matrices are derived. Differences between distance & similarity matrix

e. Sequence based database search: Tools and techniques used in sequence analysis. Pair wise and Multiple Sequence Alignments. Tools for local, global and MSA: Muscle, T-Coffee, and ClustalW.

f. Basic concept of sequence alignment – Algorithms - Needleman and Wunch, Smith waterman. Sequence analysis of Nucleic acid and Protein sequences and interpretation of the results. Applications of Sequence Analysis.

g. Sequence patterns and Evolution: Molecular evolution, Diversity, Evolution and Concept of sequence patterns, motifs, profiles, various types of pattern representation viz. consensus, regular expression and profiles. Phylogenetic analysis by PHYLIP, MEGA.

h. Nature of data used in Taxonomy and Phylogeny, Description of phylogenetic trees and types of dendrograms. Analysis, interpretation and significance of dendrograms.

i. Transcriptomics: transcriptome analysis - micro-arrays, NGS- RNA seq, Types of non-coding RNA's-lncRNAs, miRNAs, piRNAs, siRNAs ceRNAs etc. RNA databases, RNAi, RNA structure prediction tools, RNA sequence analysis, RNA regulatory networks; Transcriptome assembly, Comparative transcriptomics; short ORFs, encodeproject.

Practicals

1. Exercises on Windows/Linux/UNIX in Documentation, Networking, Internet search & Graphics.
2. Usage of Software for identification of species to authenticate biodiversity.
3. Accessing existing any five databases on the World-wide Web - PubMed/DDBJ/GENBANK/ PDB/EMBL/SCOP/etc.
4. Usage of similarity, homology and alignment software; Software for Microarray analysis – design, processing and analysis. Various versions of BLAST and CLUSTAL
5. Phylogenetic analysis using MEGA
6. Evaluation of Gene Prediction methods. Tools - GENSCAN, GENEFINDER.
7. Programming in python (Data interpretation/visualization).

References

1. Abraham Silberschatz, Peter B. Galvin & Greg Gagne 2009. Operating System Concepts with Java (8th. ed.). Wiley Publishing.

2. Attwood T.K. & Parry-Smith D.J. 2004. Introduction to Bioinformatics, Pearson Education (Singapore) Pvt. Ltd.

3. Buchanan B., Gruissem G., & Jones R. 2000. Biochemistry and Molecular Biology of Plants, American Society of Plant Physiologists, USA.

4. Claverie J.M. & C. Notredame 2003. Bioinformatics for Dummies. John Wiley and Sons.

5. David Edwards (Ed.) 2007. Plant Bioinformatics: Methods and Protocols, Humana Press, New Jersey, USA.

6. Dwyer, R.A. 2004. Genomic Perl: From Bioinformatics Basics to Working Code, Cambridge University Press, 1st South Asian Edition.

7. Ghosh & Mallick 2008, Bioinformatics: Principles and applications. Oxford University Press India.

8. Kanetkar, Y. 2008. Let Us C (13th Edition), Infinity Science Press.

9. Lesk, A.M. 2002. Introduction to Bioinformatics. Oxford University Press.

10. Lieber D.C. 2006. Introduction to Proteomics: Tools for New Biology; Humana Press, NJ.

11. Martelli, A. 2006, Python in a Nutshell. O'Reilly Media, Inc.

12. Mount, D. 2013. Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.

13. Orengo, C.A. Jones, D.T. & Thornton, J.M. 2004. Bioinformatics: Genes, Proteins and Computer. BIOS Scientific Publishers.

14. Pennington, S.R. & Dunn, M.J. (Eds.), 2002. Proteomics: From Protein Sequence to Function, BIOS Scientific Publishers, United Kingdom.

15. Rastogi S.C., N. Mendiratta & P. Rastogi 2008. Bioinformatics: Methods and Applications. Prentice-Hall.

16. Schwartz, Tom Phoenix & Brian d Foy 2005. Learning Perl (4th edition), O'Reilly & Associates.

17. Singer M. & Berg P. 1991. Genes and Genomes: A Changing Perspective; University Science Books, CA, USA.

18. Srivastava, S. K. & D. Srivastava 2004. Data structures through C in Depth (2nd Edition), BPB publication.

19. Stevens T.J. & Boucher, W. 2015. Python programming for biology, Cambridge University Press.

SEMESTER III

PSB3C12: STRUCTURAL BIOINFORMATICS

Module 1: Basic Principles relevant to Structural Bioinformatics:

Introduction and characteristics of ionic bond, covalent bond, coordination bond and hydrogen bond. Factors affecting covalent bond strength. Non-bonded interactions - electrostatic interactions and Van der Waals interactions. Hydrophobic interactions and Hydrophilic interactions. Bond stretching interactions and Metallic bond.

Principles of DNA and RNA structure, type of base pairing, Watson-Crick and Hoogstein, types of double helices A, B, Z and their geometrical as well as structural features. Principles of protein structure, classification of proteins, amino acid, structural organization of protein, primary, secondary, tertiary and quaternary structures, dihedral angle, Ramachandran plot, motifs and domains.

Module 2: Molecular interaction of DNA and Proteins:

Protein – protein interaction, protein-DNA interaction, DNA binding proteins, types of interaction of DNA with protein and small molecule, different forces involved in the interaction.

Module 3: Basic principles and methods used for structure prediction:

Wave properties, X-ray crystallography: Basic principle - X-rays, crystal systems, Bragg's law, diffraction of crystals, structure factor, atomic scattering factor, crystallization. Components and Applications of X ray crystallography in Bioinformatics - data collection, structure solution and refinement, structure validation.

Spectroscopic methods for structure determination. NMR spectroscopy: shielding constant, chemical shift, application of NMR in protein structure determination. Structural information from UV-visible IR spectroscopy, Cryo-electron microscopy.

Module 4: Methods and Tools used in Structure prediction and visualization

Methods in structure prediction: Chou-fasman method, GOR method, *Ab initio* method and measuring the accuracy of predictions using Q3, homology modeling, different steps in homology modeling.

Structure visualization tools - Rasmol, SPDBV, WEBMOL, Cn3D, VMD, molmol, chime.

Module 5: Drug discovery and synthetic biology

Chemical databases - ZINC, Pubchem, Chembl., Drug, target, ligand, substrate, drug discovery pipeline, HTS, mass screening, combinatorial chemistry, combinatorial library, CADD, QSAR, SBDD, *In-vitro*, *in- silico* methods, pharmacophore modeling, docking, De NOVO, ADME property prediction. Pharmacogenomics and pharmacoproteomics – significance and applications. DNA microarrays and Medical informatics. Introduction to synthetic biology, CAD, precise genome editing - ZFN, TALEN, CRISPR.

Practicals

1. Protparam: physico-chemical parameters of a protein sequence.
2. Computation of Isoelectric point and Molecular weight: Compute the theoretical Isoelectric point and molecular weight from Uniprot knowledge base entry or for a user sequence.
3. Use visualization tools like Swiss Pdb viewer, Jmol, Rasmol, MolMol, Rasmol, VMD.
4. Download protein and DNA from PDB and display using above program and analyze the structural features.
5. APSSP - Advanced Protein Secondary Structure Prediction Server.

6. GOR.
7. Homology Modelling - Swiss Model - An automated knowledge based protein modeling server.
8. Threading – Phyre-the Phyre automatic fold recognition server for predicting the structure and/function of your protein.
9. Ab initio – HMMSTR - prediction of the protein structure from sequence assessing tertiary structure prediction.
10. PROCHECK - verification of the stereo-chemical quality of a protein structure.
11. Usage of software to elucidate structure of biomolecules, docking of molecules & molecular designing/modelling.

References

1. Attwood T. & D. Parry-Smith 1999. Introduction to Bioinformatics (Cell and Molecular Biology in Action), Prentice Hall.
2. Baxevanis A.D. & Quellette B.F.F. (Eds.) 2004. Bioinformatics A practical guide to the Analysis of genes and Proteins, John Wiley & Sons Inc.
3. **Bosu, O. & Thokral, S.K. 2007. Bioinformatics: Experiments, Tools, Databases, and Algorithms, Oxford University Press.**
4. Bourne, P.E. & H. Weissig 2011. Structural Bioinformatics. Wiley and Blackwell.
5. Brandel C.I. & Tooze, J. 1999. Introduction to Protein structure, Garland Science.
6. Claverie, J.M. 2009. Bioinformatics - A beginner's guide, Wiley India Private limited.
7. Creighton T.E. (Ed.) 1992. Protein folding – W H Freeman & Co.
8. Eidhammer, I., Taylor W.R. & Jonassen, I. 2009. Protein Bioinformatics, Wiley**.**
9. Fersht A, 1999. Structure and Mechanism in Protein Science, W H Freeman & Co.
10. Fogel, G. & D. Corne 2002. Evolutionary computations in Bioinformatics, Morgan Kaufmann Publishers.
11. Gu J. & P.E. Bourne (Eds.) 2009. Structural Bioinformatics, 2nd Edition, Wiley-Blackwell.
12. Mount D.W. 2004. Bioinformatics – Sequence and Genome Analysis, Cold Spring Harbour Laboratory Press, New York
13. **Rastogi, S.C., Mendiratta, N. & Rastogi P. 2013. Bioinformatics: Methods and Applications: Genomics, Proteomics and Drug Discovery, Prentice Hall India Pvt. Ltd, New Delhi.**
14. **Heribert Hert 2009. Plant Stress Physiology from genomics to system biology, Wiley Blackwell.**

ELECTIVE PAPERS

SEMESTER IV

PSB4C01: APPLIED BOTANY (99 Hrs)

- Biological Nitrogen Fixation- nif genes - structure, transfer prospects. Nitrogenase biochemistry, function, Legume Symbiosis, Symbiotic Nitrogen Fixation, Regulation of nif and nod genes, biochemistry of leg-haemoglobin.
- Biofertilizers - significance. Green manuring: algae and other biofertilizers; mass cultivation of cyanobcteria biofertilizers; mass cultivation of *Azolla*; endophytic nitrogen fixers.
- Stress tolerance: - Abiotic - temperature, salinity, drought. Biotic: Pests and insects resistance – viral resistance – Transgenic approaches to develop stress tolerance – development of drought, salinity and temperature stress tolerance crops. Development of disease resistant plants by introducing *Bacillus thuringiensis* genes, Bt-cotton. Plantibodies.
- Crop protection: Molecular Aspects of Disease Susceptibility and Resistance: Transposable elements in plants, factors influencing disease resistance and susceptibility. Microbial herbicides, bacterial insecticides, entomopathogenic fungi.
- Crop Improvement in India through biotechnology: Rice, wheat, legumes, oil seed crops, forage crops, commercial crops, plantation crops, beverages crops, spices and condiments, tuber crops, and fruit crops.
- Biofuel: significance, biodiesel, potent crops for biofuel production, mechanism, transesterification reaction.
- Agricultural waste management - Waste minimization, utilization of agricultural wastes, effects of improper waste disposal.
- Cleaner technologies: Fermentation. Bioremediation - need and scope, applications - Removal of toxic chemicals from industrial waste water. Biological gas treatment systems (biofilters, biofilms, bioscrubbers). Applications of bioremediation technology
- Biodegradable plastics, Reversal of desert formation. Microbial conversion of CO2 to alcohol. Hyper - accumulators: definition, important hyper accumulators, significance. Phytoremediation: definition, types: Phytoextraction, phytostebilization, rhizofiltration; significance

Practicals (36 Hrs)

1. Isolation and identification of Nitrogen fixing bacteria/alga
2. Preparation of bioherbicides
3. Identification of plant pathogens
4. Symptoms of plant pests
5. Culturing of *Azolla*

References:

1. Purohit S.S. Biotechnology: Fundamentals and application. Agrobios.
2. Lewin B. Genes. Pearson Educational International.
3. Peter K.V. Horticulture Science Series (volume 1-12). New India Publishing Agency.
4. Nelson D.L. & Cox M.M. Lehninger Principles of Biochemistry, WH Freeman and Company.
5. Channarayappa. Molecular Biotechnology: Principles and Practices. Universities Press (India) P. Ltd.
6. Sudhir M. Applied Biotechnology and Plant Genetics. Dominant Publishers & Distributors.

7. Gilmartin P.M. & Bowler C. Molecular Plant Biology. Oxford University Press.
8. Karanth B. Selected Readings in Plant Genetics and Biotechnology. Book Enclave.
9. Ranjan R. Transgenic Plants. Agrobios.
10. Jha T.B. & Ghosh B. Plant Tissue Culture: Basic and Applied. Universities Press (India) P. Ltd.
11. Piramal V. Molecular Biotechnology. Dominant Publishers & Distributors.
12. Sudhir M. Plant Biotechnology. Dominant Publishers & Distributors.
13. Das H.K. Text Book of Biotechnology. (ed). Wiley Dreamtech India P. Ltd.
14. Park, C. 1997. The Environment. Principles and Applications. Routledge London and New York.
15. Aaradhana P.S. (Ed.) 1998. Environmental Management. Rajat Publications, Delhi.
16. Jeffrey D.W. 1987. Soil Plant Relationship an ecological approach. Croom Helm.
17. Jones H.G. 1983. Plants and microclimate: a quantitative approach to environmental Plant Physiology. Cambridge University Press.

SEMESTER IV

PSB4E02: HOTICULTURE AND MUSHROOM CULTIVATION

Module – 1 GENERAL INTRODUCTION TO HORTICULTURE (54 Hrs)

- Concept, history, nature and scope of horticulture; importance of horticulture in terms of economy, production and employment generation. Indian horticulture institutions. Different branches of horticulture, pomology, olericulture, spices and planting, ornamental horticulture.
- Basic requirements — land, water, soil, landscape, propagules, implements and practices — types of garden plants, Plant growing structures – Green house, Glass house and Mist chamber. Factors influencing growth and development- internal- seed dormancy and viability, pollen viability, seed germination, parthenocarpy, fruit growth, fruit drop and fruit ripening and external factors – soil, light, temperature, rainfall, humidity, wind.
- Methods of propagation of horticultural crops: Introduction, principles and classification of plant propagation methods. Definition, types, factors affecting, merits and demerits of seed propagation and vegetative propagation – cutting, layering, grafting and budding.
- Assessment of various factors required for plant growth and development: Nutritional requirements based on soil, tissue analysis, and field experiments; Identification of deficiency symptoms of various nutrients and methods of nutrient application. Fertilizers – Biofertilizer, Green manure, NPK, Compost – Vermicompost. Assessment of irrigation requirements for different horticultural crops and different methods of irrigation. Cultural practices - Need of spacing, pruning, thinning and training, trimming their objectives and methods at different stages of development.
- Method of production and cultivation: System of cultivation and planting systems - weed, water and fertilizer management, Plant protection, harvesting and its management, grading and packaging. Production technology of high value vegetables like Bitter gourd, *Capsicum*, *Pea* and flowers viz. Rose, Carnation, Gerbera, *Lilium*, *Chrysanthemum*.

Practicals (27 Hrs)

1. Budding – 'T' Budding and Patch Budding
2. Layering – Air Layering, Serpentine Layering
3. Grafting – Whip grafting, Cleft grafting
4. Tools and implements.
5. Analysis of soil texture
6. Analysis of soil nutrients – N, P, K
7. Estimation of Soil water and soil moisture content
8. Determination of soil pH
9. Measurement of irrigation water.
10. Prepare a report on the practices found in a horticultural farm after a visit.

References

1. Adams, C.R. & M. P. Early 2008. Principles of horticulture. Butterworth.
2. Chadha, K.L. 2001. Handbook of Horticulture, ICAR, New Delhi.
3. Chandra, R. & M. Mishra 2003. Micropropagation of horticultural crops. International Book Distributing Co., Lucknow.
4. Chattopadhyaya, P.K. 2001. A text book on Pomology (Fundamentals of fruit growing) Kalyani Publication, New Delhi.

5. Christopher, E.P. 2001. Introductory Horticulture, Biotech Books, New Delhi.
6. Edmond, J.B. T.L. Senn, F.S. Andrews & P.G. Halfacre 1975. Fundamentals of Horticulture, Tata McGraw Hill Publishing Co. New Delhi
7. George Acquaah 2002. Horticulture - principles and practices. Prentice-Half of India Pvt. Ltd., New Delhi.
8. Hartman, H.T. & Kester, D.E. 1986. Plant propagation – Principles and Practices.
9. Hartmann H.T., Kester D.E., Davies F.T., & Geneve R.L. 1997. Propagation and Practice, Prentice Hall of India, Pvt. Ltd. New Delhi.
10. Hay, R. (Ed.) 1960. The modern garden. G. Arthur Pearson Ltd. London.
11. Jitendra Singh 2006. Basic Horticulture. Kalyani Publishers, New Delhi.
12. Kumar, N.1997. Introduction to Horticulture, Rajalakshmi Publication, Nagercoil.
13. Lancaster P. 1997. Gardening in India. Revised by Bose T.K. & Mukherjee D.
14. Laurie A. & Ries V. 1956. Floriculture: fundamentals and practices Mc Graw Hill Book Co. Inc. London.
15. Macmillan 1962. Tropical planting and gardening, 5th Edn. Macmillan Co. Ltd. London.
16. Northen T.H.. & Northen R.T. 1956. The complete book of green house gardening. The Ronald Press Co. New York.
17. Pearce S.A. 1961. Ornamental tree: For gardening and roadside planting: W. H & L Collingridge Ltd. London.
18. Prakash R., Choudhary D.C. & Nagi S.S. 1991. Propagation practice of important Indian trees. IntI. Book Distributors, Dehra Dun.
19. Radford A.E. 1986. Fundamentals of plant systematics. Harper & Row Publ. Inc.
20. Shanmugavelu, K.G., N. Kumar & K.V. Peter. 2005. Production technology of spices and plantation crops. Agrobios, Jodhpur.
21. Shoemaker J.S. & Teskey B.J.E. 1965. Practical Horticulture. John Wiley & Sons. Inc. London.
22. Singh, N.P. 2005. Basic concepts of Fruit Science, International Book Distributing Co., Lucknow.

Module – 2 MUSHROOM CULTIVATION (36 Hrs)

- Mushroom Classification: Based on occurrence - Epigenous & Hypogenous, Natural Habitats - Humicolous, Lignicolous & Coprophilous, Color of spores - white, yellow, pink, purple brown & black, Morphology - fruiting layers exposed to air, fruiting layers not exposed to air, plants with predominantly pitted cap, cap saddled shape & saucer shape, Structure and texture of fruit bodies - gilled fungal & pore fungal, fruit bodies and spores. Different parts of a typical mushroom & variations in mushroom morphology. Key to differentiate Edible from Poisonous mushrooms. Classification - Ainsworth *et al.* (1973).
- Biology, cultivation, harvesting and packaging of Mushrooms: Button, Straw and Oyster – with general morphology, distinguishing characteristics, spore germination and life cycle. Nutrient Profile of Mushroom - carbohydrates, proteins, fats, vitamins & minerals. Calorific value.
- Health benefits of Mushroom: Antiviral value, antibacterial effect, antifungal effect, anti-tumour effect, haematological value cardiovascular & renal effect, in therapeutic diets.

Practicals (18 Hrs)

1. Visit to a mushroom cultivating farm

2. Training in Mushroom Cultivation
3. Spawn preparation for Mushroom Cultivation.
4. Packaging Techniques in Mushroom cultivation

References

1. Tripathi, D.P. 2005. Mushroom Cultivation, Oxford & IBH Publishing Co. Pvt. Ltd, New Delhi.
2. Pathak Yadav Gour 2010. Mushroom Production and Processing Technology, Agrobios (India).
3. Kannaiyan, S. & K. Ramasamy, 1980. A Hand book of Edible Mushroom, Today & Tomorrows Printers & Publishers, New Delhi.
4. Bahl, N. 2000. Handbook on Mushrooms, Oxford & IBH Publishing Co.

SEMESTER IV

PSB4E03: BIOETHICS, BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS (99 Hrs)

- Biotechnology and social responsibility, public acceptance issues in biotechnology, issues of access, ownership, monopoly, traditional knowledge, biodiversity, benefit sharing, environmental sustainability, public versus private funding, biotechnology in international relations, globalization and development divide.
- Introduction to bioethics: Social and ethical issues in biotechnology. Principles of bioethics. Ethical conflicts in biotechnology - interference with nature, unequal distribution of risk and benefits of biotechnology, bioethics versus business ethics.
- Biorisk and Biosafety: Definition and types, Risk Management protocols. Definition of bio-safety, Biotechnology and bio-safety concerns at the level of individuals, institutions, society, region, country and world with special emphasis on Indian concerns. Biosafety in laboratory: laboratory associated infection and other hazards, assessment of biological hazards and level of biosafety. Biosafety regulation: handling of recombinant DNA products and process in industry and in institutions (Indian context). Biosafety related to various disciplines - Ecology, GMO, Gene therapy, DNA vaccines, Plant Breeding, etc.
- Introduction and the need for intellectual property right (IPR).
    - Patent and kind of inventions protected by a patent. Patent document. Granting of patent. Rights of a patent. Searching a patent. Drafting of a patent. Filing of a patent. Implications of patenting.
    - Definition of copyright. Aspects covered by copyright. Duration of copyright. Protection of copyright. Distinction between related rights and copyright.
    - Definition of trademark. Rights of trademark. Kinds of signs used as trademarks. Types of trademark. Functions of trademark. Protection of trademark. Registration of trademark.
    - Introduction to geographical indication. Protection of geographical indication. Protection of industrial designs. Protection of new varieties of plants. Overview of Biotechnology and Intellectual Property. Licensing and Enforcing Intellectual Property. Commercializing Biotechnology Inventions.
    - UPOV - Plant Breeders Right and Farmers Right.
    - Authorities
    - Biodiversity act

Practicals (36 Hrs)

1. Documentation of any five recent Intellectual Property Rights related to biology.
2. Documentation of biosafety protocol for a tissue culture, micorbial culture, algal culture laboratories.
3. Documentation of any five examples of biorisk incidents.
4. Documentation of any five major life science trade marks.

References

1. Balasubramaniam, D., C.F.A. Bryce, K. Dharmalingam, J. Green & K. Jayaraman 2002. Concepts in Biotechnology, University Press (Orient Longman Ltd.).

2. Bourgagaize, Jewell & Buiser, 2000. Biotechnology: Demystifying the Concepts, Wesley Longman, USA.
3. Cheremisinoff, P.N., R.P. Ouellette & R.M. Bartholomew 1985. Biotechnology Applications and Research, Technomic Publishing Co., Inc. USA.
4. Madsen, K.H. & P. Sandøe 2008. The Bioethics and Biosafety of Gene Transfer. In: Tzfira, Tzvi; Citovsky, Vitaly (Eds.) Agrobacterium: From Biology to Biotechnology. Springer. pp 677-697.
5. Murray T.M & M.J. Mehlman 2000. Encyclopedia of Ethical, Legal and Policy issues in Biotechnology, John Wiley & Sons.
6. Narayanan P. 2010. Law of Copyright and Industrial Designs; Eastern law House, Delhi.
7. Parulekar A. & Sarita D'Souza 2006. Indian Patents Law – Legal & Business Implications; Macmillan India Ltd.
8. Sateesh, M.K. 2008. Bioethics and Biosafety. I K International Publishing House.
9. Wadehra B.L. 2000. Law Relating to Patents, Trade Marks, Copyright, Designs & Geographical Indications; Universal Law Publishing Pvt. Ltd., India.

SEMESTER IV

PSB4E04: PLANT TISSUE CULTURE (81 Hrs)

- Plant cell and tissue culture: introduction, history, scope.
- Basic aspects of plant tissue culture; totipotency, morphogenesis, differentiation and polarity; different culture media; components; growth regulators; growth retardants; undefined supplements; explants; sterilization; Inoculation; subculturing.
- Different types of cultures: callus - different types; cell culture; suspension culture - different types; culture methods of single cells; testing of viability of cells; application of cell and callus culture with special reference to medicinal and aromatic plants. *In vitro* morphogenesis, differentiation.
- Organogenesis - different types; factors effecting; problems related to micropropagation of woody (Medicinal) plants. Different stages of micropropagation, Somaclonal variation and its importance with special reference to medicinal and aromatic plants.
- Somatic embryogenesis: direct and indirect; Factors effecting; embryo maturation; application. Synthetic seeds and its significance.
- Production of Pathogen free plants: Different methods; Meristem culture and its importance in commercialization especially of Medicinal and Aromatic plants.
- Protoplast: Isolation and culture methods; Factors effecting; Somatic hybridization: Different types; Fusion methods. Application with special reference to medicinal and aromatic plants.
- Haploids: Different types: Androgenesis and gynogenesis, Advantages; Significance in crop improvement with special emphasis on Medicinal and Aromatic plants.
- Ovary, ovule, endosperm and embryo culture; importance. *In vitro* fertilization (recent advances) and its significance.
- Secondary metabolites: Different classes; methods of production - factors effecting yield. Biotransformation; Different types with examples. Immobilization: Different approaches: Advantages.
- Tissue culture in India with special reference to Kerala. Exploitation of medicinal plants of Kerala by Tissue culture.
- Application of Plant Tissue Culture: Clonal propagation, artificial seed production of hybrids and somaclones, drugs, products, cryopreservation and germplasm storage.

Practicals (54 Hrs)

1. Callus Culture
2. Ovule culture
3. Anther culture
4. Embryo Culture

References:

1. Adhav M. & Nagar S. 2009. Practical Biotechnology and Plant Tissue Culture, Abe books.
2. Bhojwani, S. S. & Razdan, M.K. 1996. Plant Tissue culture: Theory and Practice. Elsevier.
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4. Doods, J.H. & Roberts, L.W. 1985. Experiments in Plant Tissue culture, Cambridge University Press.
5. George, E.F. 1993-96. Plant propagation by Tissue culture-2 vols. Exegetics Ltd.
6. Narayanaswamy, S. 1994. Plant cell and Tissue culture. Tata McGraw Hill Ltd.
7. Razdan, M.K. 1995. An Introduction to Plant Tissue Culture. Oxford & IBH Publishing Co. Pvt. Ltd.
8. Smith, R. H. 2012. Plant Tissue Culture: Techniques and Experiments, Academic Press, Elsievier.

SEMESTER IV

PSB4E05: PHYTORESOURCES, PHYTOCHEMISTRY AND PHARMACOGNOSY (90 Hrs)

- Phytoresources: Origin of agriculture, World centers of primary diversity of domesticated Plants; Origin, evolution, botany, cultivation and uses of food, forage - fodder fuel, fiber, furnishings, flavours, medicinal plants and oil-yielding plants of Kerala and India. Non-wood forest products (NWFPs): Raw materials for paper making; Gums and Resins, Dyes.
- Ethnobotany and Conservation; History and development of Ethnobotany: Development of Ethnobotany in Asia with special reference to that in India. Traditional Scientific knowledge: Indigenous technical knowledge (ITK): Indigenous Agricultural knowledge (IAK), Traditional ecological knowledge (TEK), Rural people's knowledge (RPK), Traditional botanical knowledge (TBK), Integrated knowledge system (IKS), Basic methods and approaches to study traditional knowledge: Utilitarian, Cognitive and Ecological.
- Major tribes of Kerala and their dependence on plants; Scope of tribal medicines, collection of voucher specimens, verification, screening and potential applications. Problems associated with loss of biodiversity; sustainable utilization of phytoresourses; Conservation, principles, strategies, *in situ* and *ex situ* approaches, protected areas, gene banks and seed banks, international/ national initiatives.
- Phytochemistry and Pharmacognosy: Extraction, isolation and structural elucidation of natural products; chromatography techniques. Secondary metabolites, types – polyphenols, phytosterols, alkaloids, saponins, terpenes, glycosides; characteristics, extraction strategies, analysis, biosynthetic pathways and inter relationships. Pharmacognosy, morphology (macro and micro), methods, detection of adulterants, quality control of ayurvedic and herbal medicines; constituents of drugs, drug synergism and drug interactions.
- Importance and scope of medicinal plants; classification of medicinal plants; cultivation of medicinal plants; processing and utilization; storage of raw drugs; quality and evaluation; tropical medicinal plants: medicinal herbs, medicinal shrubs, medicinal climbers and medicinal trees. Ayurvedic drugs derived from whole plants, underground parts, leaves, flowers, fruits and seeds. Common adulterants used. Detailed study of medicinal plants used in ayurvedic medicines with special reference to *dasamoola, triphala* and *nalpamara* groups of ayurvedic drugs.

Practicals (45 hrs)

1. Documentation of any 10 herbal remedies of traditional knowledge.
2. Documentation of phytochemical constituents of five herbal plants, using reference books, journals and websites.
3. Herbarium preparation of dasamoola, dasapushpam and digital herbarium of triphala and nalpamara.
4. Survey and interview with traditional practitioners on medicinal plants.

References

1. Copeland, R.A. 1996. Enzymes: A practical introduction to structure, mechanism, and data analysis. VCH Publishers, New York.
2. Dennison, C. 1999. A guide to protein isolation. Kluwer Academic Publishers. Dordrecht, the Netherland.
3. Dryer, R.L. & Lata, G.F. 1989. Experimental Biochemistry. Oxford University Press, New York.

4. Hames, B.D. (ed.) 1998. Gel Electrophoresis of Proteins: A Practical Approach, (3rd Ed.). PAS, Oxford University Press, Oxford, U.K.

5. Harborne, T.C. 1981. Phytochemical Methods: A guide to modern techniques of plant analysis. Chapman and Hall, London.

6. Jain, S.K. A Manual of Ethnobotany, 2nd Edition, Scientific Publishers, Jodhpur.

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8. Meskin, M.S. 2002. Phytochemicals in nutrition and health. CRC Press.

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11. Samba Murty, A.V.S.S. & N. S. Subramanyam, Economic Botany Wiley Eastern Ltd.

12. Wilson, K. & Walker, J. 1994. Practical Biochemistry: Principles and Techniques, (4th Ed.). Cambridge University Press.

SEMESTER IV

PSB4E06: AGRICULTURAL ECOLOGY – PRINCIPLES AND APPLICATIONS (99 Hrs)

- Ecological experimentation in agriculture; basic chemical process-carbon cycle; Climate and adaptation of agricultural crops; Physical factors affecting crop-water; Energy flow in agroecosystems;
- Soil type and classification; soil properties and environmental factors; Nitrogen in agroecosystems; fertilizer elements in the environment; Macro and micronutrients and their availability to crops; Decomposition: beneficial soil organisms;
- Plant succession and competition. Weed ecology and management; Distribution and sampling of agricultural pests; introduction to insects;
- Population dynamics; pesticides and the environment; Traditional knowledge systems and agrodiversity management;
- Plant disease and environment; integrated pest management; plant-parasitic nematodes; Host plant resistance and conservation of genetic resources;
- Cropping systems and agro-ecosystems in the landscape; crop rotation and cover crops; Intercropping; conservation tillage; Mulches and organic amendments; Dry-land agriculture, irrigation and salinity; Tropical agro-ecosystems; intensive agriculture; Impact of GMOs on crop biodiversity and agroecology; Impact of agricultural policies on crop biodiversity and agroecology;
- Human population growth; sustainable agriculture; Agroecology: the future perspective.

Practicals: (36 Hrs)

1. Soil sampling and analysis for macro and micro nutrients
2. Plant water requirement assessment
3. Assessment of fertilizer inputs on crop growth
4. Assessment of planting density on crop growth
5. Impact of salinity on crop growth
6. Ecological foot print analysis

References:

1. Amaresan N., Krishna Kumar, A. Sankaranarayanan, K. Annapurna and M. Senthil Kumar, (Editors) 2020. Beneficial Microbes in Agro-Ecology: Bacteria and Fungi, Academic Press,
2. Gliesmann, S.R., 2006. Agroecology: The Ecology of Sustainable Food Systems. Technology & Engineering.
3. Gliesmann, S.R., 2006. Field and Laboratory Investigations in Agroecology. Technology & Engineering.
4. Paul A. Wojtkowski, P.A. 2004. Landscape agroecology, Haworth Press, Inc., New York. 330 pp.
5. Sangeetha J., Thangadurai D. and S. Islam, 2020. Beneficial Microbes for Sustainable Agriculture and Environmental Management, CRC Press
6. Warner, K.D. (20 07). Agroecology in Action: Extending Alternative Agriculture Through Social Networks. The MIT Press, Cambridge, Massachusetts, USA, 291 pp.

SEMESTER IV

PSB4E07: PROGRAMMING FOR BIOINFORMATICS

Module 1. BASICS IN PROGRAMMING (18 Hrs)

- Computer basics – Operating systems – Definitions, GUI (graphical user interphase) – Unix - Linux – basics and commands.
- Definition and steps involving in problem solving. Definition of problem, algorithm, charts, definition, symbol, running and debugging and computer languages.
- Definition, History and evolution of computer programming. Types of Computer Languages - Low, Assembly, High level, Compiler and Interpreter.
- Common Languages used in Bioinformatics – R, PERL, C++, PYTHON.

Module 2: HTML (9 Hrs)

- Definition of tags and attributes. Types of HTML tags, HTML tag head, body, Meta, font, anchor, img, hr, align, listing, forms, frames, tables.
- The method of computer programming using HTML and its application in Bioinformatics.

Module 3: SQL (9 Hrs)

- SQL commands – alter, create, drop, update, delete, order by, distinct, rename, inbuilt functions.
- SQL constraints - check unique not null, default, primary key, foreign key.
- Introduction to index and types of index.
- The method of computer programming using SQL and its application in Bioinformatics.
- Databases – Databases for health and medicine - database for agriculture.

Module 4. PERL (18 Hrs)

- A low and long learning curve, PERL's benefits, installing PERL on your computer, how to run PERL programs, text editors, finding help. Perl basics: Context; String literals and quoting; Lists; Intermediate iteration; I/O. Functions; Perl warning modes; Introduction to Regular Expressions; Regular expressions: Operators, Metacharacters, Character classes, basic assertions.
- Programming strategies and the programming process - Data structure, Genbank and database, Representing sequence data, a program to store a DNA sequence, concatenating DNA fragments, transcription: DNA to RNA using PERL, documentation, calculating the reverse complement in proteins, files and arrays, reading proteins in files, arrays, scalar and list context.
- Flow control code layout finding motifs counting nucleotides exploding strings into arrays, operating on strings, writing to files. Data structures and algorithms for biology - DNA Mutations and randomization, analyzing DNA, the genetic code, translating DNA into proteins
- Application in Bioinformatics.

Module 5: C LANGUAGE (27 Hrs)

- History, character set, C tokens, constants, variables, keywords and comments, instruction: type declaration instruction, arithmetic instruction, integer and float conversion, hierarchy of operation, control instructions in C.
- Operators in C - Arithmetic, logical, relational, bitwise, increment, decrement, conditional

operators, special operators, decision control structure – If statement - types of If statements, loop control structures: the while loop, for loop, do while loop, break, continue, go to label statements, switch statement, case control structure.

- Arrays, strings and function & pointers - Arrays, array initialization, types of array, strings, strlen(), strcmpy(), strcmp(), strcat(), function definition, declaration, passing values, scopes, call by values, call by reference, pointers, pointer notation, recursion, back to function call, pointers and array, array of pointers to strings (examples).
- Programming strategies and the programming process in C language.
- Application in Bioinformatics.

Practicals (54 Hrs)

1. Sequence analysis using programming languages.
2. Develop programmes for sequence analysis and diversity studies.
3. Database creation and utilization using the programmes

References

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23. Schwartz, Tom Phoenix & Brian d Foy 2005. Learning PERL (4th edition), O'Reilly & Associates, ISBN: 0-596-10105-8.

24. Srivastava, S.K. & D. Srivastava 2004. Data structures through C in Depth (2nd Edition), BPB publication.

25. Stevens T. J. & Boucher, W. 2015. Python programming for biology, Cambridge University Press.

26. Tisdall, J. 200I. Beginning Perl for Bioinformatics, O'Reilly & Associates.

27. Wünschiers R. 2013. Computational Biology - A Practical Introduction to BioData Processing and Analysis with Linux, MySQL, and R,, Springer.

MODEL QUESTION PAPER

First Semester MSc Degree Examination October 2021

PLANT SCIENCE WITH BIOINFORMATICS

(2021 admission onwards)

PSB2P01: Cell Biology, Microbiology, Mycology, Plant Pathology, Phycology, Bryology, Pteridology, Gymnosperm Botany, Environmental Science and Forest Botany

1. With the help of micro preparations identify the specimen A, B, C, Dand E with reasons (Preparations 2 identification with Reasons 2) (Phycology, Mycology. Bryology, Pteridology and Gymnosperms)5x4=20
2. Make a whole mount preparation of any two algae from the algal mixture F given (preparation 1, Labelled diagram1 identification with reasons 1) (Phycology) 3x2 =6
3. Make suitable micropreparation of material G, identify the pathogen with reasons (preparation2, identification with reasons 2)(Plant Pathology)1x4=4
4. Demonstrate streak plate method with the material H (Demonstration 2, Procedure 1)(microbiology) (Microbiology)1x3=3
5. Estimate the concentration of DO of given water sample I(Experiment -2, Calculation-1) (Environmental Science)1x3=3
6. Calculate IVI from the given data J of plant community (Enviroemntal Science) 1x2=2
7. Stain the material K (Preparations 2)(Microbiology/Mycology)1x2=2
8. Identify the forest products L and M (Binomial 0.5 and Family0.5)2X1=2
9. Spot at Sight NOPQRS6 x1 =6

Record + Submissions -12 marks

MODEL QUESTION PAPER

First Semester MSc Degree Examination October 2021

PLANT SCIENCE WITH BIOINFORMATICS

(2021 admission onwards)

PSB2P02: Angiosperm Anatomy, Embryology, Evolution, Genetics, Biostatistics, Plant Breeding, Bioinstrumentation, microbial and plant biotechnology

Time 4 Hrs **Total Marks 60**

1. TS of the material A . Prepare the double stained permanent slide and submit for valuation. Draw a labeled cellular diagaramdiagram and explain the anomaly (preparation 6, labeled diagram 2, anomaly 2)1X10=10 (Anatomy and bioinstrumentation)
2. Work out the problems B, C and D (5+4+3= 12) (Genetics and Biostatistics)
3. Extract the DNA from sample E and separate on Agarose Gel Write the procedure and leave the preparation for valuation (Extraction, 2, Gel loading 3, Procedure 2) 1x7 =7 (Bioinstrumentation/Molecular genetics/biotechnology)
4. Make suitable micropreparationsmicro preparations of F by acetolysis. Describe the pollen morphology with the help of a diagram (preparation 3, Description 2, Diagram 1)1 x6=6 (Embryology)
5. Make cytological preparation of F and and display any one stage of meiotic division, draw a neat labelled diagram and identify with reasons (Preparation 2 , identification with reasons 2, diagram 1)1x5=5 (cell Biology)
6. Demonstrate the Emasculation/hybridization technique for the given sample G (Demonstration 2 and Procedure 2) 1x4=4 (plant breeding)
7. Fill up the given incomplete flow chart H (evolution/Plant breeding/bioinstrumentation/microbial and plant biotechnology)1x2=2
8. Spot at sight I and J 2x1=2

Record + Submissions =12 makrs

MODEL QUESTION PAPER

Fourth Semester MSc Degree Examination October 2021

PLANT SCIENCE WITH BIOINFORMATICS

(2021 admission onwards)

PSB4P03: Angiosperm Morphology, Systematics, Plant Physiology and Biochemistry

Time 4 Hrs **Total Marks 60**

1. Detect the biochemical/chemicals in the given solution A using two tests, estimate the quantity using colorimeter/spectrophotometer and write down the procedure. (qualitative test 4; quantitative test 4 procedure 4) (biochemistry) 1x12=12
2. Find out the incipient plasmolytic concentration of the given leaf B, from the given molar solutions. Calculate the osmotic potential of the cell sap using the data obtained after observation. (preparation3, Graph 2, Procedure 2, Calculation 1) (physiology/biochemistry) 1x8 =8
3. Describe in technical terms, identify the family and construct the floral formula and floral diagram of the specimen C (Description 3 ; identification with reasons 2; FD-1, FF-1) (Angiosperm Systematics) 1x7=7
4. Identify the species of the angiosperm plant D with the help of Gamble's Flora of Madras Presidency (identification upto family 3 ; genus 2, species 1) (Angiosperms Systematics) 1x6=6
5. Create a dichotomous key for the given five plants, E, F. G, H, I, J and K using the morphological/floral/anatomical features. (Systematics/morphology) 1x6=6
6. Set up the experiment L using the given materials. Write down the name, aim and procedure of the experiment (Name and Aim =1.5; Procedure 1.5) (physiology) 1 x 3=3
7. Write critical notes on M, N and O 3x2=6

Record + Submissions =12 makrs

MODEL QUESTION PAPER

Fourth Semester MSc Degree Examination October 2021

PLANT SCIENCE WITH BIOINFORMATICS

(2021 admission onwards)

PSB4P04: Bioinformatics and Elective I and II

Time 4 Hrs **Total Marks 60**

1. Perform Multiple sequence alignment of the given sequence A and design a pair of primers (MSA 2 Primer Designing 1)1x 3 =3
2. Construct a cladogram based on computational analysis of the given sequence data on plants/microbes/animals B, C, D and E. 5 marks
2. Make interpretation on the given data F after performing ANOVA test (Basic bioinformatics) OR
3. Observe the data G and make appropriate graphs. (Basic bioinformatics) 6 marks
4. Make a protein structure for the given data H. (Structural bioinformatics) 4 marks
5. Perform BLASTN/ BLASTP/ BLASTX and TBLASTN on the given sequence data'I" in FASTA format. (Structural bioinformatics) 4 marks
6. Find the homologous genes of ……...plant similar and identify the genomic coordinates of the given sequence/region and to identify oligonucleotides and restriction sites - interpret the results 6 marks

Marks for Elective 1 and Elective 2 = 18

Record + Submissions =12 marks

PSB1C01: CELL BIOLOGY AND MOLECULAR GENETICS

MODULE WISE WEIGHTAGE OF QUESTIONS

	Module 1	Module 2
SECTION A	1/2	½
SECTION B	2/5	3/5
SECTION C	4/8	4/8
SECTION D	5/10	5/10
Total	12/25	13/25

MODEL QUESTION PAPER

First Semester MSc Degree Examination October 2021

PLANT SCIENCE WITH BIOINFORMATICS

(2021 admission onwards)

PSB1C01: Cell Biology and Molecular Genetics

Time 3 hrs Max Marks 60

Draw diagrams wherever necessary

SECTION A: Answer any two questions; one from each bunch 2x 8 = 16 marks

1. A
or
B
2. A
or
B

SECTION B: Answer any three questions 3x 5= 15 marks

3.
4.
5.
6.
7.

SECTION C: Answer any five questions: 5 x 3=15 marks

8.
9.
10.
11.
12.
13.
14.
15.

SECTION D: Answer any seven questions: 7x2=14 marks

16.
17.
18.
19.
20.
21.
22.
23.
24.
25.