COURSES OF STUDIES

for

M.Sc. Botany
(2022-2023)

FAKIR MOHAN UNIVERSITY
Vyasa Vihar, Balasore-756089, Odisha

P.G. Department of Botany
M.Sc. Botany

PROGRAMME OUTCOMES (POS)

PO1. To prepare the students to became a role player/ transformer/ leader/ entrepreneur to address the challenges of plant science education & research and to find solutions to meet the sustainable development goals at local, regional, national and global context.

PO2. To generate resourceful degree holders enabled with professional and research oriented knowledge and skills so as to enhance their employability that significantly helps in the process of individual empowerment, societal development and overall nation building.

PO3. To transfer the contemporary knowledge to the students to address the real life issues with strong sense of ethical values, scientific intellectuality, social responsibility and national integrity.

PROGRAMME SPECIFIC OUTCOME

Plant science is a combination of basic and applied science. Conventional studies have been supplemented with knowledge on molecular techniques. The course has been designed to advantage students to study on various aspects of botany along with its practical applications. After studying this subject course students can take up teaching at different levels, research work in various institutes and organisation, doctoral work, environment impact study, biodiversity assessment, entrepreneurship, scientific writing relevant to current topic.

Outcome 1	Identification of flora in an area. Learn about diversity in relation to habitat correlate with climate change, land and forest degradation. Apply knowledge in botany in agriculture through study of plant pathology. Paleobotany to trace evolution of plants
Outcome 2	Understand the multi functionality of plant cells and its products in manufacturing of natural products and there wide spread industrial application
Outcome 3	To know about molecular and physiological response of plants and implement that knowledge in plant breeding area to develop plant species with higher tolerance to biotic and abiotic stresses

Outcome 4	The program in Botany is designed in such a way as to equip students for competitive exams like CSIR NET, GATE, SET etc to pursue higher studies
Outcome 5	Application of knowledge in botany enables students to maintain high level of scientific excellence in botanical research by designing experiments, analyze and interpret the data in a logical and valuable conclusion.
Outcome 6	Learning and developing analytical and integrative problem solving approaches.

P.G. Department of Botany
M.Sc. Botany
COURSE STRUCTURE

Paper Code	***Paper Name***	***Marks*** *(Internal + End term)*	***Credit***
Semester I			
BOT-411	Plant Diversity- I (Microbiology/Algae/Fungi)	40 + 60	4
BOT-412	Systematic Botany I	40 + 60	4
BOT-413	Plant Metabolism-I	40 + 60	4
BOT-414	Plant Biochemistry	40 + 60	4
BOT-415	Cell and Molecular Biology	40 + 60	4
BOT-416	Practical	100	8
Semester II			
BOT-421	Plant Diversity- II	40 + 60	4
BOT-422	Genetics and Plant Breeding	40 + 60	4
BOT-423	Plant Biotechnology and Tissue culture	40 + 60	4
BOT-424	Ecology and Environmental Biology	40 + 60	4
BOT-425	Environmental Biotechnology And Management	40 + 60	4
BOT-426	Practical	100	8
Semester III			
**********	Fakir Mohan Studies	**Non Credit Course**	
BOT-531	Systematic Botany II	40 + 60	4
BOT-532	Plant Metabolism II	40 + 60	4
BOT-533	Developmental Botany	40 + 60	4
BOT-534	Instrumentation, Biostatistics and Computer application	40 + 60	4
BOT-535	Basics of Plant Science *(Choice based paper)*	40 + 60	4
BOT-536	Practical	100	8
Semester IV			
BOT-541	Grand Viva	100	4
BOT-542	Review Work	100	4
BOT-542	Dissertation Work *	200	8
Total Marks		**2200**	**100**

* At the beginning of the Third semester, the student will select a topic for project work in consultation with teacher assigned to him/her by the Department. The Dissertation work (Field work/Experiment work /Review work) be initiated at the beginning of Semester III. The student will compile the findings in the form of a project report which will be submitted to the Department during the 4th Semester Examination.

Note: The underlined portions in the detailed syllabus of each paper are to be self studied by the students.

MARKING/ EVALUATION PATTERN

During the 2022-23 admission session, Post-Graduate degrees offered by the University will follow a continuous evaluation system as per the marks distribution mentioned below.

<table>
<tr><th></th><th>Theory papers</th><th>Practical Papers</th><th>Dissertation Work (in 4th Sem)</th></tr>
<tr><td>Total marks per paper</td><td>100 Marks</td><td>100 Marks</td><td>300 Marks</td></tr>
<tr><td>Credit per paper</td><td>4</td><td>8</td><td>12</td></tr>
<tr><td rowspan="3">Internal Examination</td><td>Best of the two quizzes
10 Marks</td><td rowspan="3">----</td><td rowspan="3">---</td></tr>
<tr><td>Written (Mid Sem)
20 Marks</td></tr>
<tr><td>Presentation and Home Assignment
10 Marks</td></tr>
<tr><td rowspan="3">End Term Examination</td><td rowspan="3">60 Marks</td><td>Experiment
70 Marks</td><td>Rationale and quality of project work: 100 Marks (based on the presentation)</td></tr>
<tr><td>Practical Record
10 Marks</td><td>Dissertation Report
60 Marks</td></tr>
<tr><td>Viva-Voce
20 Marks</td><td>Viva-Voce
40 Marks</td></tr>
<tr><td>Total no of papers in all semesters</td><td>14</td><td>4</td><td>1</td></tr>
<tr><td>Total marks</td><td>1400 Marks</td><td>400 Marks</td><td>200 Marks</td></tr>
<tr><td>Grand Total</td><td colspan="3">2200 Marks</td></tr>
<tr><td>Total Credits</td><td colspan="3">100</td></tr>
</table>

Scheme of Internal Evaluation (Theory):
Each theory paper consists of five units and irrespective of the credit hours assigned, will be of 100 marks, out of which, 40 will be internal marks (continuous evaluation) and 60 will be end term examination marks. There will be three components of internal evaluation – Quiz, Mid Term Written Test and Presentation & Home Assignment as per the details below.

Component	Unit(s)	Marks	Remarks
Quiz – I	I	10	Best of the two quizzes of 10 marks each will be considered
Quiz – II	III		
Mid Term (Written)	I & II	20	Students are required to make presentations and home assignments on selected topics from the **self-study** section
Presentation & Home Assignment	All	10	
Total	**I – V**	**40**	

VALUE-ADDED/ ADD-ON COURSES

A student of M. Sc. in Botany shall undertake one or more value-added courses of 2 – 4 credits each offered by the University and an online course of up to 4 credits under the MOOC platform, preferably during the 2nd/ 3rd semester, the performance of which may be reflected in the final grade sheet issued by the University or in a separate report card issued for the purpose by the competent authority. Fees towards enrollment and examination of such courses have to be borne by the concerned candidate.

GUIDELINE FOR CREDIT TRANSFER UNDER MASSIVE OPEN ONLINE COURSES PLATFORM

Reference: Gazette of India (Extraordinary) Part-III, Section-4 No. 295, UGC (Credit Framework for Online Learning Courses through SWAYAM) Regulation, 2016, dated 19/07/2016.

Following modalities have been approved "to introduce the credit transfer policy in academic curriculum for the Massive Open Online Courses (MOOC's) offered through SWAYAM (Study Webs of Active-Learning for Young Aspiring Minds) Portal".

1. Students of MSc Botany programme are allowed to opt for credit transfer against the online course completed under SWAYAM platform during any semester of the programme enrolled except the last semester. The transferred credit against the online course completed will be in addition to the regular 96 credits that are offered at the University/Department in physical mode.

2. Opting an online course under SWAYAM is purely optional depending on the necessity of an individual student and the programme in which he/she is enrolled. It must be noted that, online courses through SWAYAM should not be more than 20% of total courses offered in a particular semester of a programme.

3. The SWAYAM platform generally notify the list of the online learning Courses going to be offered in the forthcoming Semester during June and November every year, on its website https://swayam.gov.in.

4. After notification by SWAYAM, the students interested to register for few courses under SWAYAM platform offered by other reputed Universities should normally apply in advance (before commencement of the course) to the respective Head of the Department. Keeping in view of the academic requirements of the Degree, the Board of studies of the subject/Teachers council of the Dept. shall permit for credit transfer of the online course. While permitting the same the body must

keep in view the following points: a) There is non-availability of similar course in the Department due to lack of suitable teaching staff b) The facilities for offering the elective papers (courses), sought for by the students are not on offer/scheme in the Institution, but are available on the SWAYAM platform. c) The courses offered on SWAYAM would supplement the teaching-learning process in the Institution. d) Online courses through SWAYAM should not be more than 20% of total courses offered in a particular semester of a programme.

5. It is the responsibility of the student attend the online course with own arrangement and he/she must fulfil all requirements of the online course to get the course completion certificate. The registration/examination fee of the course is to be borne by the student. After obtaining the certificate, the student must submit a verifiable copy of the certificate to concerned Head of the Department with an application requesting to transfer the credit.

6. Credit transfer applications received before examination form fill up of a particular semester will be verified at the Dept and the Head of the Dept/Coordinator will recommend to incorporate the transferred credit in the mark sheet issued to the student by Controller of Examination.

SELF SYUDY

25% of each unit of a theory paper is earmarked for self-study by students as per UGC directives. For completion of the portion in a particular semester, the course teacher is required to take one/ two introductory classes in the beginning, one/ two summarizing classes at the end and few doubt clearing classes in between, if required. Students are required to make presentation on selected topics from the self-study section during the class in order to assess their understanding of the subject and take remedial measures, if needed. The portion earmarked for self-study has been underlined in the syllabus.

REGULATION OF GENERAL ACADEMIC MATTERS

1. CREDIT HOURS

One credit shall signify the quantum of teaching imparted corresponding to one hour of theory class and one and half hours Laboratory/ Seminar/ Project work per week during a semester in respect of a particular course. For field study outside headquarters, one working day will be considered as three teaching hours. However the field study should not exceed 15 days (including Sundays) in one semester. The minimum classes for different Credit Courses (theory) in each semester shall be as follows:

1- One Credit hour courses = 12 classes minimum
2- Two Credit hour courses = 24 classes minimum
3- Three Credit hour courses = 36 classes minimum
4- Four Credit hour courses = 48 classes minimum

The minimum credit hour requirement for the Master Degree shall be 96 (Ninety Six) credits and the residence required for Master Degree shall be continuous four semesters from the first date of registration and **the maximum time allowed to complete the Master Degree shall be 8 (Eight) semesters**.

2. CHOICE BASED PAPER,

The paper **BOT- 535: Basics of Plant Science** offered by our Department which is to be opted by the students of other Department/Course during third semester of the programme is a *Choice Based* Paper.

3. FAKIR MOHAN STUDIES PAPER

In the third semester of the course, there will be a non credit paper entitled " Fakir Mohan Studies" in which the performance of the students will be evaluated in terms of grade (Grade A= 70 % or more; B= 50 % or more but less than 70 %; C= 30 % or more but less than 50 %).

4. GRADE

The grade awarded to a student in any particular course shall be based on his/ her performance in all the tests conducted during a semester and shall be awarded at the end of the semester. The grade in each course is expressed in a numerical value in 10.00 scale. The marks of a student shall be converted to 10.00 point scale and the point scored thereby shall be called the 'grade point' in that course. Respective 'Grade Point Average' (GPA) and 'Overall Grade Point Average' (OGPA) shall be awarded at the end of each semester and all semester respectively. In order to pass in a semester examination **in P.G. Course** a candidate must secure a minimum 4.0 GPA (in aggregate for all theory papers) with a minimum of 3.00 GP in individual Theory (**Internal and Semester Examination combined, not separately)** and 4.0 GP in Practical. **In P.G. Courses, no separate pass mark for Internal Examination, but appearing in the Internal Examination is mandatory.**

If any student fails to appear the Internal Examination due to some valid reason or secures poor mark, he/she may apply to HOD for a Second Internal Examination who may allow this with approval of the Teachers' Council and this

Examination would be open to all the students. The best mark secured by the student out of two Internal Examinations should be credited to the student and this should be forwarded by HOD to the Controller of Examinations. In all cases, the Internal Examinations should be completed well before the commencement of Semester Examination of the concerned Semester. Once the marks of a particular Internal Examination is forwarded by HOD to Controller of Examinations, it is final forever. Under no circumstances Internal Examination is permitted after the commencement of Semester Examination of a particular Semester.

If a student fails in any paper in the Semester Examination, then he/she has to clear that paper by appearing the Semester Examination, not the Internal Examination, of that particular paper when University will conduct the said Examination in the next Academic Session in its due time. Under no circumstances any Special Examination will be held for any student after publication of the results of a particular Semester.

A student who seeks re-addition of his/her grade in a paper shall be allowed to do so by submitting an application to the controller of examinations along with a prescribed fee within 21 days of publication of said results. All such cases/complaints if any shall be disposed of by the Examination Committee within 21 days of last date of application and necessary corrections if any shall be reflected in the grade sheet.

The candidates shall have to appear in all the units (internal as well as end term examination) of a semester examination to be eligible to be declared pass provided he /she secures minimum pass grade. Provisional certificates will be issued only after passing all the four semester examinations.

4.1 GRADE POINT AVERAGE (G.P.A.)

Grade Point Average (GPA) of a semester shall be calculated as:

$$\text{GPA} = \frac{\sum[(\text{Credit in each course}) \times (\text{Grade point in that course})]}{\text{Total no. of Credits in that semester}}$$

Where, the summation is taken over all courses in a given semester. GPA shall be rounded up to 2 decimal points.

Example: In a semester, a candidate secured following Grade Points in five papers.

Paper Code	Credit hour	Maximum Marks	Mark Secured	Grade point
411	4	50	37	7.4
412	4	50	42	8.4
413	4	50	35	7.0
414	4	50	24	4.8
415	8	100	73	7.3

$$\text{GPA} = \frac{(4 \times 7.4) + (4 \times 8.4) + (4 \times 7.0) + (4 \times 4.8) + (8 \times 7.3)}{24} = 7.03$$

4.2 OVERALL GRADE POINT AVERAGE (O.G.P.A.)

It is the average of accumulated Grade Points of a student, worked out by dividing the cumulative total of Grade Points by the cumulative total of Credit Hours of the entire course covered and completed by a student during all the semesters. For the first semester of the programme the GPA and OGPA shall be the same.

$$\text{OGPA} = \frac{\sum[(\text{GPA of each semester}) \times (\text{Total Credits in that semester})]}{\text{Total no. of Credits of all the semesters}}$$

Where, the summation is taken over all semesters in a given programme. OGPA shall be rounded up to 2 decimal points. For merit lists in case of equality, the OGPA shall be calculated beyond two decimal places if necessary.

Example: A candidate secured following GPAs in four semesters

Semester	**CH**	**GPA**
First	24	7.49
Second	24	8.30
Third	24	7.85
Fourth	24	8.8

$$\text{GPA} = \frac{(24 \times 7.49) + (24 \times 8.30) + (24 \times 7.85) + (24 \times 8.8)}{96} = 8.11$$

4.3. CONVERSION OF GRADES TO MARKS AND CLASSIFICATION OF RESULTS UNDER COURSE CREDIT SYSTEM

The OGPA can be converted to percentage of marks in the following manner.

Percentage of Marks = OGPA × 10

A student after successful completion of all the semesters, Degree shall be awarded in the following manner.

OGPA	≥6.0	FIRST CLASS
OGPA	≥5.0 < 6.0	SECOND CLASS
OGPA	≥4.0 < 5.0	THIRD DIVISION
OGPA	<4.0	FAIL

5. REQUIREMENT FOR ATTENDENCE

A candidate shall be required to attend 75 % of lectures and practical classes during a semester. Condonation may be granted by the Teachers' Council only to the extent of 15 % in exceptional cases (Illness, accident, mishap in the family, deputation by University/Deptt.). When a candidate has been deputed by the University to represent the University/ State for any activity, the lectures delivered during his/her absence for the purpose shall not be counted towards the calculation of attendance provided the student submits a certificate to that effect from the appropriate authority.

If a student is not allowed to fill up the examination form due to lack of attendance for a particular semester or he/she was not able to fill up the said form due to any other reasons then **it will be considered as discontinuance of course.** He/she has to take readmission in the same semester by depositing the requisite semester fee. He/she will study as per the current syllabus and should complete the course within **the maximum time allowed time of 8 (Eight) semesters from the date of first admission**. Discontinuous candidates shall not be considered in the merit list

6. FILLED UP THE FORM BUT ABSENT IN THE EXAMINATION

If a student has filled up the examination form and is unable to appear a semester examination in some or all papers the Academic Committee of the Department shall consider his/her case for admission into the next higher semester only in the following case.

(a) When he/she is hospitalized.

(b) When he/she is not able to appear in the examination due to serious illness or death of parents, brothers, sisters, spouse or children,

(c) When he/she is met an accident of serious nature;

(d) When the Department /University or any official directive deputes him.

(e) When he/she or his/her parents, brothers, sisters, spouse or children faces any natural calamity

A student failing to appear semester examination in some or all papers due to some valid reasons as mentioned above may be admitted to the next semester. Such a student shall produce sufficient proof in favour of his/her reason for not being able to appear in some or all papers of the semester Examination. Such cases shall be considered by the Teachers' Council of the Department for giving permission for admission into next semester. Such students shall appear the repeat the Semester Examination in the next academic session.

7. PROCEDURE FOR REPEAT/IMPROVEMENT

7. 1. Repeat: A student may be allowed to repeat in any practical/theory papers in a semester, in which he /she has failed, within a period of eight semesters for P. G. Programmes from the date of first registration to the programme. Such students shall have to apply to the Head of the Department in plain paper before fifteen days of the commencement of the said examination. If allowed by the Head, he/she shall deposit the requisite fee, as notified by the Controller of Examinations, to appear the paper(s) during the conduct of the concerned examination by the University.

7.2. Improvement: After the publication of results, a student may be allowed to improve his/her performance in not more than 50 % of the theory papers in a semester, within eight semesters from the first registration to the programme. Improvement is allowed only once for a particular semester for those papers only, in which a candidate has secured less than 50 % of marks. In such a case the highest mark secured in each paper will be considered for computing the mark.

Candidates appearing in repeat/improvement examination shall not be considered in the merit list.

8. PROMOTION TO THE NEXT SEMSTER

A student shall be admitted to the next higher semester only when he/she has appeared in all the papers of the previous semester examination. However, a student failing to appear semester examination in some or all papers due to some valid reasons may be admitted to the next semester as mentioned under section 6.

1st Semester

Subject Code	Subject Name	Credit	Int. Mark	End Term Mark
BOT-411	Plant Diversity- I (Microbiology/Algae/Fungi)	4	40	60

Objective	Microorganisms can be found in almost every natural element on the planet and they play key roles in nutrient cycling, biodegradation, climate change, food spoilage, the cause and control of disease, and biotechnology. So, the objective of this paper is to enhance the knowledge of students about the structure, reproduction and role of different microorganisms.
Pre-Requisites	Basic knowledge about the prokaryotic and eukaryotic cells.
Teaching Scheme	Regular classroom lectures with visual information.

Detailed Syllabus

Unit	Topics	Hours
I	History and development of microbiology, Bergey's manual for classification of microbes, Whittaker's 5 kingdom concept, Carl Woese's 3 domain classification, Characteristics of prokaryotic and eukaryotic microbes, Isolation, Culture and maintenance of microorganisms, Roles of microbes in agriculture and industry, Microbial growth, Factors influencing growth of microbes.	10
II	Structure and reproduction of Eubacteria, Cyanobacteria, Archaea, Actinomycetes, Mycoplasma, Rickettsiae, Spirochaetes, Virus, Viroids, Prions, Biofertilizers: cyanobacteria, *Rhizobium*, Mycorrhizae and *Azotobacter*.	10
III	Algae in diversified habitats (terrestrial, freshwater and marine), Classification based on pigment, food reserve and flagella, Thallus organization, Reproduction. Life cycles in algae. Salient features of Chlorophyta, Bacillariophyta, Dinophyta, Phaeophyta and Rhodophyta, Algal bloom and toxins, Algae as food, Seaweed cultivation.	10
IV	Classification of fungi, Structure and reproduction of Phycomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes. Degeneration of sex in fungi, Nutrition in fungi, Heterothallism, Heterokaryosis. Fungal toxin	10
V	Plant diseases caused by Viruses, Bacteria, Mycoplasma & Fungi. Disease symptoms, Modes of infection and dissemination, Disease resistance, Defence mechanism and control methods, Host-parasite relationship.	8
	Total	48

Course outcome	On completion of this course the students will learn about the 1. Origin, evolution and diversity of microbial life 2. Utilization of micro-organisms for economic and industrial purposes 3. Diversity, systematic, morphology, life cycle and economic importance of algae and fungi

Text Books:

1. Brock Biology of Microorganisms by M.T. Magdigan J.M. Martinako, J. Parker.
2. Microbiology by M. J. Pelczar, E.C.S. Chan and N.R.Kreig.
3. General Microbiology by RY.Stainer, J.I.Ingharam, M.I. Wheelis.
4. Algae by B.R. Vashistha.
5. Fungi byB.R. Vashistha.

Subject Code	Subject Name	Credit	Int. Mark	End Term Mark
BOT-412	Systematic Botany I	4	40	60

Objective	Major objectives of this paper are to understand scientific naming of Plants, classification of plants on the basis of their evolutionary history and molecular studies, learning the floral structure of important plant families and economic importance of plants.
Pre-Requisites	Basic knowledge about different plant parts and terminology.
Teaching Scheme	Regular classroom teaching with practical demonstration with local flora.

Detailed Syllabus

Unit	Topics	Hours
I	**Principles of Plant Nomenclature:** Salient features of ICN: Typification, Author citation, Effective & Valid publication, Principle of priority and its limitation, Rejection of names; The species concept.	7
II	**Floristic Studies**: Concept and significance of Herbarium, Herbarium Methodology; Important herbaria of the World, Documentation & incorporation of data, assessment of threatened species Botanic gardens.	7
III	S**ystems of classifications**: Comparative accounts and Critical analysis of major system of classifications: Benthem& Hooker, Engler-Prantl, Hutchinson, Takhtajan, APG system, Cladistics in taxonomy: Concepts and methodology, parallelism and convergence, cladistics in classification of plants.	10
IV	**Phylogeny of flowering plants:** Range of floral structures in major dicot groups: Ranales, Rosales, Asterales and Lamiales, and in monocot groups: Poales, Scitaminae and Orchidales. Studies on major families: Rosaceae, Asteraceae, Rubiaceae, Lamiaceae, Cyperaceae and Poaceae	12
V	**Economic Botany:** Origin and domestication of cultivated plants, Centres of diversity and Centres of origin of crop plants, Usage of plants as food, Forage, Fodder, Fibre and oil-yielding crops. Medicinal and aromatic plants of Odisha, Important fuel wood, timber yielding plants, non wood forest products (NWFP)	12
	Total	48

Course outcome	On completion of this course the students will learn about the 1. Principles of plant taxonomy and importance of plant identification. 2. Origin, distribution and utilization of economically important plants.

Text Books:

1. Current concepts in plant taxonomy by V.H. Heywood and D. N. Moore.
2. Taxonomy of Angiosperms by AVSS Sambamurthy
3. Economic Botany by A.F. Hill.
4. Economic Botany by H.P. Pandey

Subject Code	Subject Name	Credit	Int. Mark	End Term Mark
BOT-413	Plant Metabolism-I	4	40	60

Objective	The basic objective of this paper is to elaborate on the various physiological processes occurring in the plants. To help the students to understand the water relation of plants with respect to various physiological processes, to explain the significance of photosynthesis and nitrogen metabolism in plants. To introduce the concept of stress physiology in plants
Pre-Requisites	Knowledge of anatomical and cellular organisation of plants
Teaching Scheme	Regular class room lectures, seminars, tutorials and group discussions encouraging interactive sessions between student and teacher, practical classes helping students to clear their understanding of the basic concepts of plant physiology

Detailed Syllabus

Unit	Topic	Hours
I	Plant Water relations: Physical properties of water, Importance of water to plant life. Diffusion, imbibition and osmosis, concept & components of Water potential. Absorption and transport of water and ascent of sap. Transpiration: Definition, types of transpiration, structure and mechanism of opening and closing mechanism of stomata, Antitranspirants.	12
II	**Mineral nutrition:** Essential elements (macro and micronutrients) and their role in plant metabolism, deficiency symptoms. Mineral uptake, methods of study and use of nutrient solutions, criteria for essentiality, chelating agents.	12
III	**Membrane Transport:** Solute transport through plasma membrane, Role of aquaporins, channel protein, carrier protein and pumps in active and passive transport. Mechanism of solute accumulation in vacuoles, Phloem loading & unloading, source-sink relationship, Mass-flow (pressure flow) hypothesis and its critical evaluation.	7
IV	**Photochemistry and photosynthesis:** General concept of photochemistry, Photosynthetic pigments and light harvesting complexes, Photo-oxidation of water, mechanisms of electron and proton transport & ATP synthesis. Carbon assimilation: C3, C4 cycle and the CAM pathway photorespiration & its significance	7
V	**Respiration:** Glycolysis, anaerobic respiration, TCA cycle, electron transport system. Mechanism of oxidative phosphorylation.	10
	Total	48

Course outcome	On completion of this course the students will learn about the 1. Movement of water, nutrients and ions in plants at molecular and organismal level 2. Method of transport through xylem and phloem 3. Mechanism and importance of carbohydrate and lipid metabolism in plants

References: Book

1. Plant Physiology by Salisbury F.B. and Ross C.W.,
2. Plant Physiology, L. Taiz, and E. Zeiger,
3. Introductory Plant Physiology by C.R Noogie and G.J.Fritz.
4. Introduction to Plant Physiology by W.G. Hopkins.
5. Life Processes in Plants by A. W. Galston.

Subject Code	Subject Name	Credit	Int. Mark	End Term Mark
BOT-414	Plant Biochemistry	4	40	60

Objective	The objective of this paper is to comprehend different concepts related to plant biochemistry. To understand the properties and significance of different biomolecules like carbohydrates, lipids, proteins & nucleic acids. To study the concept of Enzymology along with regulation of enzyme activity and mechanism of action.
Pre-Requisites	Basic knowledge of different biomolecules present in plants
Teaching Scheme	Regular class room lectures, seminars, tutorials and group discussions encouraging interactive sessions between student and teacher, practical classes helping students to clear their understanding of the concepts.

Detailed Syllabus

Unit	Topic	Hours
I	Amino acids: Classification and properties, Acid–base properties, The Peptide bond, ionization behaviour of peptides, biologically active peptides. Levels of protein structure, Determination of primary structure of protein. Three dimensional structure of proteins (Secondary, tertiary and quaternary structures, structural patterns: motifs and domains), Protein denaturation and folding. Protein sorting: Targeting of proteins to organelles, Mechanism of sorting and regulation of target transport.	8
II	Carbohydrates: Classification, configuration and conformation of monosaccharides, sugar derivatives, important disaccharides. Biosynthesis of starch and sucrose, Structural and storage polysaccharides, glucosaminoglycans, proteoglycans, glycoproteins and glycolipids	8
III	Metabolism: Amino acid catabolism (transamination, oxidative deamination and urea cycle), Protein degradation (proteosomal pathway) and Solid phase synthesis of peptides. Carbohydrate metabolism: Glycolysis, TCA cycle, pentose-phosphate pathway.Gluconeogenesis, glycogen metabolism, regulation of carbohydrate metabolism, Oxidative phosphorylation, electrontransport and ATP synthesis.	8
IV	Enzymes: General properties, nomenclature and classification, extraction and assay Michaelis-Menten kinetics and its significance, Brigg's-Halden modification, determination of Vmax and Km Mechanism of enzyme action: general acid-base catalysis, covalent catalysis, metal catalysis. Mechanism of action of RNAse, Lysozyme and Chymotrypsin Enzyme inhibition: competitive, non-competitive inhibition,determination of Ki, allosteric regulation, covalent modification.	12
V	Nucleic Acid: Structure of Nucleic acids, DNA structure, A, B & Z forms, Lipids: Classification, storage lipids, structural lipids (glycerophospholipid and sphingolipids), signalling lipids, cofactors, terpenes, and pigments. Coenzymes and vitamins Biosynthesis and oxidation of fatty acids, regulation of fatty acid metabolism, glyoxylate cycle	12
	Total	48

Course outcome	On completion of this course the students will learn about the 1. The structures and function of basic components of cell especially cell membranes, organelles and important bio-molecules. 2. The underlying principle of cell cycle, division and regulation.

References: Book

1. Lehninger's Principles of Biochemistry by D. Nelson and M. Cox
2. 2. Biochemistry- Dr. U. Satyanarayan and Dr. U. Chakrapani
3. 3. Biochemistry – by Jeremy M. Berg, John L. Tymoczko, Lubert Stryer

Subject Code	Subject Name	Credit	Int. Mark	End Term Mark
BOT-415	Cell and Molecular Biology	4	40	60

Objectives	The basic objective of the course is to strengthen the student basics on cellular structure and function and their role in lively activities
Pre-requisites	Knowledge on cellular structure of living beings
Teaching Scheme	Class room lectures with use of ICT and Practical's of cytological and physio-bichemicals

Detailed Syllabus

Unit	Topic	Hours
I	**Cell Wall**: Structure & functions; Biogenesis; Growth. Plasma membrane: Structure, Models, Electrical properties of membrane & functions; Sites for ATPases, Ion carriers, Channels and pumps; Receptors Plasmodesmata: Structure; Role in movement of molecules & macromolecules; Comparison with gap junctions. Cell shape & motility: The cytoskeleton, Organization & role of microtubules and microfilaments	8
II	**Cell organelles**: Chloroplast: Structure, Function, Biogenesis and Genome organization. Mitochondria: Structure, Function, Biogenesis and Genome organization. Other cellular organelles: Structure & functions of Golgi apparatus, Lysosomes, Endoplasmic reticulum.	8
III	**Nucleus**: Structure, Nuclear pore complex, Nucleosome organization. Nucleolus and Chromatin ultrastructure and DNA packaging in eukaryotic chromosome, Centromere: types, structure and function. Replication, Damage & repair	8
IV	Transcription: mechanism of transcripton in prokaryotes and eukaryotes, transcription factors, Operon concept, m-RNA transport, tRNA, Micro-RNA and Importance of 16SrRNA. Ribosomes: Structure, Site of protein synthesis, Mechanism of translation initiation, Elongation & termination.	12
V	Cell cycle and apoptosis: Control mechanisms, Role of cyclins & cyclin dependent kinases (Cdks), Retinoblastoma & E2F proteins, , Cytokinesis & cell plate formation, Mechanism of programmed cell death, Signal Transduction – Basic concepts; Receptors and G-proteins; Cyclic AMP cascade	12

Course outcome	On completion of this course the students will learn about the 1. The structures and function of basic components of cell especially cell membranes, organelles and important bio-molecules. 2. The underlying principle of cell cycle, division and regulation.

References: Book

1. Molecular Biology of the Cell by B. Albert, D. Bary, J. Lewis, M. Raff, K. Roberts and J.D. Watson.
2. Molecular Cell Biology by J. Damell, H. Lodish and D. Baltimore
3. Cytogenetics by P.K. Gupta
4. Molecular Cell Biology by H.Lodish, A. Berk, S.L. Zipurskt, P. Matsudaire, D . Baltimore and W.H. Darnell.

Sub. Code	Paper Name	Credit	Internal Mark	End Term Mark
BOT-416	Practical	8	00	100 Experiment : 70 Marks, Practical Record: 10 Marks Viva-Voce: 20 Marks

Paper BOT 416: Practical relating to BOT-411, BOT-412, BOT-413, BOT-414, BOT-415

- General idea on instruments used in microbiology laboratory
- Preparation and sterilization of media (Nutrient Agar, Nutrient Broth, Czapeck-Dox), Plating, Tubing, Slanting of media
- Gram staining and acid-fast staining of bacteria
- Isolation of bacteria in pure culture
- Study of commonly occurring cyanobacteria
- Measurement of length/breadth/diameter of microbial cell/spore using ocular and stage micrometer
- Study of principles of spectrophotometer and verification of Beer-Lambert's law
- Effect of substrate concentration on activity of any enzyme and determination of Km value. (Acid Phosphatase, peroxidase, catalase)
- Extraction of pigment from leaves and preparation of absorption spectra for chlorophylls and
  carotenoids
- Preparation of standard curves for quantification of protein, carbohydrate and reducing sugar
- Quantification of soluble and total protein and total carbohydrate contents of plant samples
- Isolation of Chloroplast and study of protein profile of RUBISCO by SDS-PAGE
- Practical related to Biostatistics and computer application
- Study of micro and macro algae in the field and in the laboratory (preparation of temporary and permanent materials and identification).
- Study of morphology and reproductive structures of algae belonging to different classes through permanent microscopic preparations and preserved specimens.
- Measurement of Dispersion, [Standard Deviation (SD), Standard Error of Mean (SEM), Variance] of the given plant sample
- Statistical analysis of biological samples and study of test of significance by t-test, $\chi 2$ test, and F-test
- Isolation of plant DNA and quantification of extracted DNA by spectrophotometric method.
- Separation of DNA by gel electrophoresis.

2nd Semester

Subject Code	Subject Name	Credit	Int. Mark	End Term Mark
BOT-421	Plant Diverstiy II	4	40	60

Objective	Main objective of this course is to know the characters and evolution of different major plant groups, such as bryophytes, pteridophytes and gymnosperms.
Pre-Requisites	Basic knowledge about phanerogams and cryptogams
Teaching Scheme	Regular classroom teaching with practical demonstration through field visits

Detailed Syllabus

Unit	Topics	Hours
I	Origin, Evolution and classification of Bryophytes, Ecological significance of Bryophytes, Structure and reproduction of Anthocerotales, Marchantiales, Metzgeriales, Jungermanniales, Sphagnales, Funariales and Polytrichales, Progressive sterilization of sporogenous tissues, Evolution of Gametophytes in Bryophytes.	12
II	Origin, Evolution and classification of Pteridophytes, General account of Psilophytales, Fossil Lycophytes, Sphenophytes, Fossil ferns. Stellar Evolution. Origin of Heterospory, Heterospory and seed habit.	10
III	Structure, Reproduction and Evolution of Psilopsida, Lycopsida, Sphenopsida and Pteropsida, Soral evolution, Origin, Morphology and Evolutionary significance of Sporocarp.	10
IV	Evolution and classification of Gymnosperms, Geological time scale, Fossilization process, General account of Pteridospermales, Cycadeoidales, Pentoxyllales, Fossil Ginkgoales, Cordaitales and fossil Coniferales.	8
V	Structure and Reproduction of Cycadales, Ginkgoales, Coniferalesand Gnetales. Complexities and Gametophytes in Gymnosperm, Evolution of female Gametophytes.	8
	Total	48

Course outcome	On completion of this course the students will learn about the 1. Vegetative and reproductive structures of earlier plants and their importance. 2. Processes involved in fossilization, types of fossils and their importance

Text Books:

1. Bryophyta by B.R. Vashistha, A.K. Sinha and A. Kumar
2. Textbook of Bryophyta by Afroz Alam
3. Pteridophyta by B.R. Vashistha
4. Gymnosperms Structure & Evolution by C.J. Chamberlain
5. The Gymnosperms by C. Biswas & B.M. Johri

Sub Code	Subject Name	Credit	Int. Mark	End Term Mark
BOT-422	Genetics and Plant Breeding	4	40	60

Objective	The basic objective of this paper is to introduce the students to the concept of genetics including principles governing Mendelian inheritance, gene interactions and gene expression at molecular, cellular and organism level to help students develop quantitative problem solving skills to genetic problems
Pre-Requisites	Knowledge of genes, chromosomes, eukaryotic cell cycle and mitotic and meiotic cell cycle
Teaching Scheme	Regular class room lectures, seminars, tutorials and group discussions encouraging interactive sessions between student and teacher, solving problems relating to different aspects of genetics, practical classes helping students to clear their understanding of the basic concepts of genetics

Detailed Syllabus

Unit	Topic	Hours
I	Mendel's experiments and laws of inheritance, gene interaction with epistasis or modified mendelian dihybrid ratios: masking gene action, supplementary gene action, duplicate gene action, complementary gene action, self incompatibility in plants; Polygenic inheritance, Maternal effects and cytoplasmic inheritance, mitochondrial & chloroplast genome.	8
II	Sex chromosomes, Chromosomal sex determination: XX-XY, XX-XO and ZZ-ZW systems, Compound sex chromosome, Meiotic behavior of chromosomes: Primary & Secondary non-disjunction, Genic balance theory of sex determination, Sex influenced dominance by sex-linked gene expression. Sex determination in plants.Population genetics: Hardy-Weinberg's Law, genetics of quantitative traits in population.	14
III	Linkage groups: Complete and incomplete linkage. Crossing over: Relationship between genetic and cytological crossing over, Relationship between crossing over and chaisma formation, molecular mechanism of crossing over. Detection of linkage & Linkage maps: Test cross, test for linkage on the basis of F2 generation, LOD score, gene mapping, three point test cross in Drosophila, construction of linkage maps, identification of particular linkage groups with specific chromosome, physical distance and map distance Interference and coincidence, Mitotic Recombination, Recombination within gene.	14
IV	Structural and numerical alterations in chromosomes: Spontaneous and induced mutations, physical and chemical mutagens, chromosomal aberrations, meiotic behavior of deletion, duplication, inversion and translocation. Euploids and aneuploids-classification, origin, induction, role of polyploidy in evolution and practical significance in crop improvement.	6
V	Plant Breeding: Method of plant breeding – introduction & selection (Pedegree, back cross, mass selection, bulk method), Male sterility and Heterosis breeding, Mutation breeding. Heterosis and Inbreeding depression, Hybrid and Synthetic varieties.	6
	Total	48

Course outcome	On completion of this course the students will learn about the 1. Basic principle of Mendelian inheritance, gene interaction and gene expression 2. Mechanism behind generation of variation in trait 3. The science and techniques of plant breeding

Text books: **1.** Genetics by M. W. Strickberger
2. Principles of Genetics by Gardner, Simmons and Snustad (2009)

Sub Code	Subject Name	Credit	Int. Mark	End Term Mark
BOT-423	Plant Biotechnology and Tissue culture	4	40	60

Objectives	The basic objective of the course is to introduce the students mind regarding applied areas of biology in commercial scale through crop improvement and year round basis of seedlings and agriproducts
Prerequisites	Ideas on applied areas of Plant sciences and Crop improvement
Teaching Scheme	Class room lectures with use of ICT and Practical's of Tissue culture, PCR and other biotechnological tools

Detailed Syllabus

Unit	Topic	Hours
I	Plant cell, Tissue & organ culture: History, Scope and concept of cellular differentiations, Totipotency, Tissue-culture media, Fundamental aspects of morphogenesis: organogenesis and somatic embryogenesis, Clonal propagation, and importance, Hybrids through embryo rescue. Androgenesis and production of haploids.	9
II	Cryopreservation. Synthetic seeds, Seed Bank, Gene bank, Cell lines. Somatic hybridization and cybridization. Protoplast Isolation, Factors affecting Protoplast Isolation, Culture and plant regeneration, Protoplast fusion-chemical fusion & electrofusion mechanism & techniques, Culture , plant regeneration and factors affecting protoplast culture	9
III	Production of Callus and cell suspension culture, Production of somaclonal variants. Secondary metabolites in cultures. Somatic hybridization and cybridization: Selection of heterokaryotic fusion products, Biochemical selection and physical selection (micromanipulation, flow cytometric characterization and cell sorting), Analysis of hybrids, Somatic hybrids and Cybrids for Crop Improvement	12
IV	Recombinant DNA technology: Gene cloning-principles, Cloning vectors-plasmids, Phages, Cosmids & phagemids; Artificial chromosomes, Polymerase Chain Reaction-principles, Types and applications, RT-PCR; Genomic and c DNA libraries; Construction of recombinant DNA molecules and their mobilization into bacteria; Analysis of recombinant clones, DNA sequencing.	10
V	Genetic Engineering of plants: Methods for gene transfer to plants, *Agrobacterium* mediated and direct gene delivery, Gene tagging, Detection of foreign gene and gene products; Southern blotting, Northern blotting and Western blotting; Chloroplast transformation, Gene targeting, Transgenic plants for crop improvement, Intellectual property rights, Possible ecological risks and ethical concerns.	8

Course outcome	On completion of this course the students will learn about the 1. Concepts, tools and techniques related to in vitro propagation of plants. 2. Different methods used for genetic transformation of plants, with the use of different vectors for plant transformation 3. Principles and methods used for phenotypic, genetic and molecular analysis of transgenic plants 4. Basic requirements and knowledge of plant tissue culture in various fields for biology

References: Books

1. Plant Biotechnology, the genetic manipulation of plants by A. Slater, N. Scott & M. Fowler
2. Plant Tissue Culture: Theory & Practice by S.S. Bhojwani & M.K. Razdan
3. Introduction to Plant Biotechnology by H.S. Chawla

Subject Code	Subject Name	Credit	Int. Mark	End Term Mark
BOT-424	Ecology and Environmental Biology	4	40	60

Objective	Main objective of this paper is to know, how the organisms interact with each other and their environment. Also, to understand the nature of environmental influences on individual organisms, their populations, andcommunities and ultimately at the level of the biosphere.
Pre-Requisites	Basic knowledge on biotic and abiotic components of ecosystems.
Teaching Scheme	Regular classroom teaching with practical through field visits

Detailed Syllabus

Unit	Topics	Hours
I	Abiotic and biotic components; Primary and secondary production, methods of measuring productivity, pattern of primary production and biomass in the major ecosystem of the world. Energy flow: food chain, food web and Ecological pyramid in terrestrial and aquatic ecosystems. Biogeochemical cycles - Carbon, Nitrogen, Sulphur, Phosphorus.	12
II	Community ecology: concept, structural analysis: Qualitative and Quantitative analysis of plant community. Ecological niche, Ecotone and edge effect. Competition theory and coexistence. Succession - models of succession(monoclimax and polyclimax theories), Mechanism of succession in natural communities - facilitation, tolerance, and inhibition.	12
III	Population ecology: Basic concept, population characters, biotic potential. Population growth: population growth curves, laws of population growth, regulation of population density, limiting factors of population growth, population fluctuation, r & k selection, Population interactions: positive and negative interactions, interspecific relationship. Population regulation: competitive exclusion, density dependent and independent regulation.	12
IV	Conservation Biology: Basic concept of Biodiversity; Biodivesity of Indian sub-continent: Biodiversity hotspots, Biological invasions & biodiversity; Biodiversity conservation strategies: *in-situ* and *ex-situ* conservation, Protected Area Network-Biosphere reserves, National park, Sanctuary, Community conservation area.	6
V	Environmental pollution: Kinds and sources of pollutants, classification of pollutants, Soil pollutants: sources, types, and effects; modification of plant productivity by soil pollution, effects on soil microflora. Water & Air pollutants: fates and effects, role of plants for pollution control, Global climate change, green house effect, ozone depletion- causes and effects.	6
	Total	48

Course outcome	On completion of this course the students will learn about the 1. Structure, function and working of ecological systems at different spatial and temporal scales. 2. Models depicting population and community level dynamics 3. Global environmental problems.

Text Books:

1. Ecology by E.P Odum
2. Ecology and Environment by P.D. Sharma
3. Fundamentals of ecology by M.C. Dash
4. Biodiversity and Conservation by G. Melchias

Sub Code	Subject Name	Credit	Int. Mark	End Term Mark
BOT-425	Environmental Biotechnology And Management	4	40	60

Objective	To acquire knowledge on how biotechnological approach can diminish various environmental problems. Also to understand different processes related to industrial microbiology
Pre-Requisites	Basic knowledge of microbiology and biotechnology
Teaching Scheme	Regular classroom teaching with practical through industrial visits

Detailed Syllabus

Unit	Topic	Hours
I	**Phytoremediation And Phytomining**; Concept of Phytoremediation and Phytomining, Methods of Phytoremediation: Phytoextraction, Rhizofiltration, Phytodetoxification, Phytovolatilization, Phytochelation, Hyperaccumulators and their role, Biomining, Bioleaching, Biosorption, Phytoremediation of Organics, Biotransformation of toxic metal pollution	10
II	**Biodegradation of organic pollutants**: Degradation of industrial pollutants, measurement of biodegradability, aerobic and anaerobic degradation, degradation of pesticides, hydrocarbon removal, molecular basis of pesticide removal, bioaccumulation	10
III	**Energy management and bio-fertilizers:** Biomass, bioenergy, biofuels, energy plantation, petroplants, biogas, bioethanol and biohydrogen generation, plants as natural pesticides, integrated pest management	9
IV	**Fermentation** : an overview; industrially important microorganisms,Types of fermentation processes - Solid-state and liquid-state (stationary and submerged) fermentations; batch, fed-batch (eg. baker's yeast) and continuous fermentations; Economics of a fermentation process, determination of cost and its recovery, cost cutting strategies,biological waste treatment, hygiene and safety in fermentation industries	9
V	**Bioreactors**, design and components of basic fermentor, specialized fermentors for specific purposes – continuous, anaerobic, for gaseous nutrients, for treatment of wastes, trickle flow reactors,cyclone reactors, submerged types, tube reactors, packed bed reactors, lab scale to pilot to industrial –scale up process, online monitoring	10
	Total	48

Course outcome	On completion of this course the students will learn about the 1. Application of biotechnology in addressing environmental issues and their management 2. Different techniques of industrial microbiology

Text Books:

1. Environmental Biotechnology: by S V S Rana. Rastogi Publications
2. Environmental Biotechnology: by Bimal C. Bhattacharyya & Rintu Banerjee. Oxford Higher Education

Sub. Code	Paper Name	Credit	Internal Mark	End Term Mark
BOT-426	Practical	8	00	100 Experiment : 70 Marks, Practical Record: 10 Marks Viva-Voce: 20 Marks

Paper BOT-425: Practical relating to BOT-421, BOT-422, BOT-423, BOT-424, BOT-425

- Study of temporary & permanent preparation for microscope observation of external and internal features of vegetative and reproductive structure of important genera of Bryophytes
- Study of temporary and permanent preparation of vegetative and reproductive structure of Pteridophytes
- Study of temporary and permanent preparation of vegetative and reproductive structure of Gymnosperms
- Squashing techniques for study of mitosis and meiosis in onion root tip and flower bud. Use of camera lucida to study chromosomes & calculating the magnification
- To find out mitotic index of dividing cells of Allium cepa root tips
- Comparative karyotypic analysis of two species of a genus
- Preparation of tissue culture media
- Techniques of surface sterilization and plant regeneration via organ culture
- Study of plant communities by Quadrat method and determine Frequency, Density and Abundance.
- To determine the minimum size of the Quadrat by species area curve method.
- Isolation of plant DNA and quantification of extracted DNA by spectrophotometric method.
- Separation of DNA by gel electrophoresis.

3rd Semester

Subject Code	Subject Name	Credit	Int. Mark	End Term Mark
BOT-531	Systematic Botany II	4	40	60

Objective	Major objectives of this paper are to understand scientific naming of Plants, classification of plants on the basis of their evolutionary history and molecular studies, learning the floral structure of important plant families and economic importance of plants.
Pre-Requisites	Basic knowledge about different plant parts and terminology.
Teaching Scheme	Regular classroom teaching with practical demonstration with local flora.

Detailed Syllabus

Unit	Topics	Hours
I	**Modern taxonomy:** Morphology, anatomy, palyonology, embryology, cytology and phytochemistry as taxonomic tools.	7
II	**Chemotaxonomy**: compounds useful in Plant Taxonomy- Primary, Secondary metabolites and Semantides. Stages of chemotaxonomic investigation. Use of flavonoids, alkaloids & terpenoides in taxonomic study. Genetic techniques in systematics: Genetic analysis of characters and phenetic variation- Dominance, Epistasis, Pleotropy.	7
III	**Taxonomic literature**: Floras, Monographs, Revisions, Manuals, Indices and Dictionary. Botanical keys-Types, Structure & uses: application of Act keys. Use of computers in Taxonomy: Electronic herbarium and digital database preparation (DELTA). Taxonomy of cultivated plants and names of hybrids.	10
IV	**Germplasm Conservation**: Exploration and collection of plant genetic resources. *In-situ* conservation, *Ex-situ* conservation (Gene bank & Cryopreservation). Role of National Bureau of Plant Genetic Resources (NBPGR), International Plant Genetic Resources Institute (IPGRI) and National Rice Research Institute (NRRI) in conservation and utilisation of plants.	12
V	**Application of systematics**: Application of Molecular markers, RAPD, AFLP, RFLP for phylogeny and establishment of genomic relationship. **Ethnobotany:** Definition; Methods & techniques used in ethnobotany. Impact of Ethnomedicine for development of herbal medicines and drug discovery.	12
	Total	48

Course outcome	1. Students will be acquainted with experimental taxonomy & compilation of taxonomic literature. 2. They will be acquainted with various biotechnological approaches for biodiversity conservation and will be informed with role of Institution of repute in conservation & utilisation of plants.

References:

1. **An Introduction to systematic Botany and Ecology**, J. N. Mitra
2. Lawrence, G.H.M. (1951). **Taxonomy of Vascular Plants.**
3. Maheshwari, P. (1950). **An Introduction to the Embryology of Angiosperms**. McGraw-Hill, New York
4. Radford, A.E., W.C. Dickson, J.R. Massey and C.R. Bell (1974). **Vascular Plant Systematics**, Harper and Row Publishers, New York.
5. Stebbins, G.L. (1950). **Variation and Evolution in Plants**. Columbia University Press, Ney York.
6. Willis, J.C. (1973). **A Dictionary of Flowering Plants**, Cambridge Univ. Press, Cambridge.
7. **Current Concepts in Plant Taxonomy**, VH Heywood & DM Moore, Academic Press, London.
8. **Plant Systematics**, SB Jones & AE Luchsinger, McGraw Hill Book Company, New York.
9. **Plant Systematics** for 21st Century, B Nordenstam, Gazaly, Kassas, Port Press Ltd., London.
10. **Fundamentals of Plant Systematics**, AE Radford, Harper & Row

11. **Plant Taxonomy & Systematics**, CA Stace, Publications Edward Arnold Ltd.
12. **Diversity & Classification of FI Plants**, AC Takhtajan, Columbia Univ. Press, New York.
13. **An Introduction to Plant Taxonomy**- Jeffrey. C, 1968, J. A. Churchill Ltd., London.
14. Shivranjan, V. V. (1990). **Introduction to the Principles of Plant Taxonomy** 2nd ed. Oxford & IBH publishing Co. New Delhi.
15. Sneath. P.H.A. and Sokal, R.R. (1973).**Numerical Taxonomy** W.H. Freeman, San Franisco.
16. Takhtajan, A. (1969). **Flowering Plants: Origin and Disposal** (Tr. C. Jeffrey)
17. Grant, W.F.(ed). (1984), **Plant Biosystematics**, Academic Press, London & New York.
18. Heslop-Harrison, J.S. (1953) **New Concept in Flowering Plant Taxonomy**. Heinemann, London.
19. Heslop-Harrison, J.S.(1991) **The Molecular Cytogenetic of Plants**, J.cell.Sci 100:15-21
20. Heywood, V.H. (ed) (1968) **Modern Methods in Plant Taxonomy**, A.P, London & N.Y.
21. Huxley, J.S. (1940). **The New Systematics**. Clarendon Press, Oxford.
22. Jain, S.K. and Rao. R.R. (1978). **A Handbook of Field and Herbarium Methods**. Today and Tomorrow's Pub, New Delhi.

Sub Code	Subject Name	Credit	Int. Mark	End Term Mark
BOT-532	Plant Metabolism II	4	40	60

Objective	The objective of this paper is to know the importance and scope of plant physiology. To understand the concept of cell signaling in plants to co-ordinate their activities in response to changing conditions that guide plants cycle of growth, flowering and fruiting. To enhance the knowledge of plants response to pathogens at structural, biochemical and molecular level.
Pre-Requisites	Basic knowledge of plant physiology
Teaching Scheme	Regular class room lectures, seminars, tutorials and group discussions encouraging interactive sessions between student and teacher, weekly projects, practical classes helping students to clear their understanding of the concepts.

Detailed Syllabus

Unit	Topic	Hours
I	**Stress Physiology:** Responses of plants to biotic and abiotic stresses, mechanism of stress resistance and tolerance, water deficit and drought stress, salinity stress, metal toxicity, freezing and heat stress, HR and SAR, oxidative stress.	10
II	**Plant growth regulators:** Physiological effects, biosynthesis and mechanism of action of auxins, gibberellins, cytokinins, ethylene, abscisic acid and brassinosteroids. Role of mutants in understanding hormone action.	10
III	Photoreceptors: phytochromes, cytochromes, phytotropin, UV-B and their role in regulation of plant morphogenesis. Flowering: Phenomenon of flowering, photoperiodism and its significance, endogenous clock	7
IV	**Nitrogen metabolism:** Overview, biological nitrogen fixation, mechanism of nitrate uptake and reduction, nitrate and ammonium assimilation, Nif genes, NOD genes, leg haemoglobin, amino acid biosynthesis.	7
V	Secondary metabolites: Primary and secondary metabolites; Types and biosynthesis of secondary metabolites – terpenes, phenolics and alkaloids. Significance of secondary metabolites	14
	Total	48

Course outcome	On completion of this course the students will learn about the 1. Role of nitrogen cycle in environment 2. Role of hormones and signaling compounds in plant response to various conditions 3. Management of stress by plants 4. Importance of secondary metabolites

Text books: 1. Plant Physiology by L. Taiz, and E. Zeiger,

2. Introduction to Plant Physiology by W.G. Hopkins

Sub Code	Subject Name	Credit	Int. Mark	End Term Mark
BOT-533	Developmental Botany	4	40	60

Objectives	The basic objective of the course is to study the anatomical feature of shoot ,root leaf flower and fruits with emphasizing their developmental feature and variations for production of mutant seedlings and their mechanistic approach
Prerequisites	To Understand the anatomical feature with regard to developmental process
Teaching Scheme	Class room lectures with use of ICT and Practical's of anatomy and developmental process

Detailed Syllabus

Unit	Topic	Hours
I	Differentiation and Development: Difference between animal and plant cell development with unique features in plant cell development, Use of mutants in seedling development; Molecular analysis of shoot apical meristem; Root apical meristem & leaf growth, Leaf development and phyllotaxy, Transition to flowering,	9
II	Vascular tissue differentiation of root, Shoot & leaf, Floral development & homoeotic mutants in *Arabidopsis* &*Antirrhinum.* Developmental Biology: Molecular and cytological analysis of endosperm & fruit development, Fruit ripening and its manipulation. Polyembryony, Apomixes	9
III	Seed germination; Seed dormancy, Bud dormancy, Types & programmed cell death in life cycle of plants, Metabolic changes associated with senescence and its regulation. Influence of hormones & environmental factors on senescence. Male gametophyte: Structure of anthers, Microsporogenesis	12
IV	Role of tapetum, Pollen development, Male sterility, Male nuclei dimorphism and hybrid seed production, Pollen germination, Pollen tube growth and guidance, pollen storage, Pollen allergy, Pollen embryos. Female gametophyte: Ovule development, Megasporogenesis, Organization of the embryo sac, Structure of the embryo sac cells,	10
V	Floral characteristics, Pollination mechanisms and vectors, Breeding systems, Structure of pistil. Developmental Embryology: Pollen-stigma interactions, Sporophytic and gametophytic self incompatibility (cytological, biochemical and molecular aspects), Double fertilization, in vitro fertilization.	08

Course outcome	On completion of this course the students will learn about the 1. Role of each cell structure in plant development 2. Fundamentals associated with development, differentiation and structure of various plant organs 3. Metabolic and physiological changes occurring in plant during development

References: Book

1. The Embryology of Angiosperms by S.S. Bhojwaniand S.P. Bhatnagar
2. An Introduction to Plant Structure and Development by Beck,
3. Mechanisms in Plant Development by Ottoline Leyser and Stephen Day

Sub Code	Subject Name	Credit	Int. Mark	End Term Mark
BOT-534	Instrumentation, Biostatistics and Computer application	4	40	60

Objective	The objective of this paper is to introduce the concept of application and significance of different sophisticated techniques involving high end technology, computer programs and statistical methods to solve various plant biology related problems.
Pre-Requisites	Basic knowledge of computer and physics of higher secondary level.
Teaching Scheme	Regular class room lectures using ICT tools as and when required, computer classes, problem solving sessions, group discussions encouraging interactive sessions between student and teacher, practical classes to understand the handling and working of different instruments used in the study of plant biology

Detailed Syllabus

Unit	Topic	Hours
I	Principle of operation and Instrumentation of Light, Fluorescence and Electron MicroscopesUltraviolet-visible absorption spectroscopy: Principle, Instrumentation and application, Fluorescence spectrophotometry: Principle, Instrumentation and application Radioisotope techniques: Nature of radioactivity, isotopes in biochemistry, measurement of radioactivity (carbon dating, Geiger-Muller counting and liquid scintillation counting).	12
II	The Ph electrode. Centrifugation techniques: Basic principles of sedimentation, Types of centrifuges, Types of rotors, Methods in preparatory ultracentrifugation (differential and density gradient centrifugation).	8
III	Chromatographic techniques: Principles of chromatography (Adsorption and Partition chromatography), Planar chromatography (Paper and Thin-layer chromatography), Column chromatography (Gas chromatography, Gel exclusion/permeation chromatography, Ion exchange chromatography, Affinity chromatography, HPLC).	8
IV	Electrophoretic techniques: General principles, support media, electrophoresis of proteins (SDS-PAGE, native gels, gradient gels, isoelectric focusing gels and two dimensional gels), electrophoresis of nucleic acids (Agarose, pulse-field and sequencing gels). Blotting techniques (Southern, northern and western blotting).	10
V	Statistical Methods: Sampling methods, sampling distribution, measures of central tendencyanddispersion, Probability distribution: normal, binominal and poisson distribution. Sample homogeneity and heterogeneity analysis by binomial and poisson distribution, Parametric and nonparametric statistics: paired and unpaired t-test and $\chi 2$ test, analysis of variance: one factor and two factor ANOVA, linear and non-linear regression and correlation.	10
	Total	48

Course outcome	The students will know about 1. The working principle of sophisticated techniques used for studying living organisms. 2. Concepts of basic statistical tests and data analysis

Reference: Books:

1. Introduction to instrumentation in life sciences, by Anjana Sharma, Prakash Singh
2 .Introduction to Practical Biostatistics by B.N. Misra & M.K. Misra.

Sub Code	Subject Name	Credit	Int. Mark	End Term Mark
BOT-535	Basics of Plant Science	4	40	60

Objectives	To aware students other than the M. Sc. Botany programme about the importance of plant science education
Pre-Requisites	Choice based paper for the students other than the M. Sc. Environmental Science course
Teaching Scheme	Regular class room lectures with use of ICT tools as and when required.

Detailed Syllabus

Unit	Topic	Hours
I	Five kingdom classification and salient features of Monera, Protista and Fungi, Lichens, Viruses and Viroids, General Characteristics & Classification of plants into major groups Algae, Fungi, Bryophyte, Pteridophyte & Gymnosperms and their economic importance	9
II	Characteristics of prokaryotic & eukaryotic cells, Structure & Function of plant cell & its cell organelles: Cell Wall, Cell Membrane, Cytoplasm, Nucleus, Chloroplast, Mitochondria, Endoplasmic Reticulum, Vacuoles, Lysosomes, Golgi bodies	9
III	Morphology of Angiosperms: Roots, Stem & Leaf; Flower development; Different tissue organisation (Simple & Complex tissue).	12
IV	Photosynthesis: light & dark reaction; Respiration: Glycolysis, Krebs cycle, ATP generation; Plant growth regulators: Auxin, Gibberellic Acid, Cytokinins, Abscisic acid, Ethylene: Synthesis & their function.	10
V	Environmental Biology: Definition, Levels & types; In-situ and Ex-situ conservation, Protected Area Network, Biosphere Reserve	08

Course outcome	On completion of this course the students will learn about the 1. Diversity of plant kingdom and their respective significance 2. Structure and function of plant cell and various cellular organelles and higher tissue organisation 3. Mechanism of important physiological processes and role of phytohormones in plant development 4. Various types of biodiversity and its conservation strategies

References: Book

1. College Botany by Dr. B P Pandey

Sub. Code	Paper Name	Credit	Internal Mark	End Term Mark
BOT-535	Practical	8	00	100 Experiment : 70 Marks, Practical Record: 10 Marks Viva-Voce: 20 Marks

Paper BOT- 535: Practical relating to BOT-531, BOT-532, BOT-533, BOT-534

- Learning about laboratory safety rules and basic requirements.
- Local field trip to acquaint the students with flora of the local area.
- Collection, description and identification of locally available wild Angiospermic taxa pertaining to nomenclaturally important category.
- Herbarium methodology: Collection, Identification, Preservation, Mounting and Housing.
- Study of wood anatomy through preparation of slides/permanent slides.
- Economic valuation of biodiversity using Belal and Springuel.
- Collection and study of plants of ethno-botanical and other economic importance.
- Separation of amino acids by paper chromatography.
- Determination of rate of photosynthesis in green plants by floating disc method.
- To determine the leaf area using graph paper.
- To determine diffusion pressure deficit by weight method.
- To study the absorption spectrum of different plant pigments.
- To determine carbohydrate content from different samples.
- Estimation of total protein content form different samples by Lowry's method.
- Determination free amino acid content from different samples by Ninhydrin method.
- To determine the effect (Heat/Detergent) on the permeability of plasma membrane in Beet root.

4th Semester

ELECTIVE – I PLANT PHYSIOLOGY

Sub Code	Subject Name	Credit	Int. Mark	End Term Mark
BOT-541-A	ADVANCED PLANT PHYSIOLOGY I	4	40	60

Objectives	The basic objective of the course is to study the life process of plant and their physiological and biochemical phenomenon including factors which have direct and indirect effect on plant growth and development.
Prerequisites	To Understand the plant life process and effect of internal and external factors
Teaching Scheme	Class room lectures with use of ICT and Practical's of physiology and Biochemistry

Detailed Syllabus		
Unit -I	Plant Water relations: Physical properties of water, Importance of water to plant life. Diffusion, imbibition and osmosis, concept & components of Water potential. Absorption and transport of water and ascent of sap. Transpiration: Definition, types of transpiration, structure and opening and closing mechanism of stomata.	15
Unit -II	**Mineral nutrition & Solute Transport:** Essential elements (macro and micronutrients) and their role in plant metabolism, deficiency symptoms. Mineral uptake and Solute transport through plasma membrane, Role of aquaporins, channel protein, carrier protein and pumps in active and passive transport.	15
Unit-III	**Photosynthesis:** Photochemistry, Photosynthetic pigments, photosynthetic light reactions, photo- phosphorylation, carbon assimilation pathways: C_3, C_4, and CAM, Photorespiration and its significance. Translocation of organic solutes: mechanism of phloem transport, source-sink relationships.	10
Unit-IV	**Respiration:** Glycolysis, anaerobic respiration, TCA cycle, electron transport system. Mechanism of oxidative phosphorylation.	04
Unit-V	**Lipid Metabolism:** Types of lipids, alpha and beta-oxidation of fatty acids.	04

References: Book

6. Plant Physiology by Salisbury F.B. and Ross C.W.,
7. Plant Physiology, L. Taiz, and E. Zeiger,
8. Introductory Plant Physiology by C.R Noogie and G.J.Fritz.
9. Introduction to Plant Physiology by W.G. Hopkins.
10. Life Processes in Plants by A. W. Galston.

Sub Code	Subject Name	Credit	Int. Mark	End Term Mark
BOT-542-A	ADVANCED PLANT PHYSIOLOGY II	4	40	60

Objective	The objective of this paper is to know the importance and scope of plant physiology. To understand the concept of cell signaling in plants to co-ordinate their activities in response to changing conditions that guide plants cycle of growth, flowering and fruiting. To enhance the knowledge of plants response to pathogens at structural, biochemical and molecular level.
Pre-Requisites	Basic knowledge of plant physiology
Teaching Scheme	Regular class room lectures, seminars, tutorials and group discussions encouraging interactive sessions between student and teacher, weekly projects, practical classes helping students to clear their understanding of the concepts.

Detailed Syllabus		
Unit	**Topic**	**Hours**
I	Nitrogen metabolism- Symbiotic and asymbiotic N_2 fixation in plants, Molecular mechanism of nitrogen uptake, Role of nitrogenase enzyme complex, Nod factors, Nif genes, leghaemoglobin: structure & function, Nitrate uptake and reduction in plants. Biosynthesis of aminoacids.	10
II	Growth and development: Definition, phases and kinetics of growth. Biosynthesis and Physiological effects of phytohormones - Auxins, Gibberellins, Cytokinins, ABA, Ethylene and Brassinosteroids. Physiology of flowering -photoperiodism, role of phytochrome in flowering; Vernalization. Physiology of Scenescence and Ageing.	10
III	General Aspects, Seed Germination and Seedling Growth, Shoot, Leaf and Root Development, Floral Induction and Development, Senescence and Programmed Cell Death (PCD), Signal Transduction – Basic concepts; Receptors and G-proteins; Cyclic AMP cascade; Phospholipid and Ca^{2+}-calmodulin cascade; MAP kinase cascade (Second messengers).	7
IV	Types of receptor, Major pathway examples, Molecular Mechanism of Hormone Action, Role of mutants in understanding hormone action. Molecular mechanisms of light perception, signal transduction and gene regulation. Biological clocks and their genetic and molecular determinants.	7
V	Introduction to plant pathology, survival of plant pathogens, dispersal of plant pathogens, phenomenon of infection process: biochemical and molecular, R protein, Avr protein,R gene mediated resistance, Phytoalexins,Plantibodies, Role of enzymes in pathogenesis, Role of growth regulators in plant pathogenesis, Defense mechanism in plants, Plant disease epidemiology, Principles of plant disease management	14
	Total	48

Text books: 1. Plant Physiology by L. Taiz, and E. Zeiger,

2. Introduction to Plant Physiology by W.G. Hopkins

Sub. Code	Paper Name	Credit	Internal Mark	End Term Mark
BOT-543-A	Practical	8	00	100 Experiment : 70 Marks, Practical Record: 10 Marks Viva-Voce: 20 Marks

Physiology Practical related to Paper BOT-541-A, 542-A

1. To determine the osmotic pressure of vascular sap of Rhoeo-discolor/ Tradescantia leaves by plasmolytic method.
2. To determine the Diffusion Pressure Deficit (water potential) of potato tuber by weighing method/Density method.
3. To measure the rate of photosynthesis in leaves.
4. To determine the chlorophyll a / chlorophyll b ratio in C3 and C4 plants.
5. To estimate the percentage of total reducing sugar in a plant.
6. To measure the rate of respiration in germinating seedling.
7. Qualitative tests of different Phytochemicals using plant sample.
8. Estimation of free acids in Bryophyllum.
9. Determination of Q10 (Temperature coefficient) of photosynthesis (light reaction).
10. To study the effect of cold treatment /scarification on breaking dormancy.
11. To study the effects of light (Phytochrome) kinetin on seed germination
12. Bioassay for quantitative estimation of Auxin in coleoptiles tips

ELECTIVE – II (BIOSYSTEMATICS)

Subject Code	Subject Name	Credit	Internal Mark	End Term Mark
BOT-541-B	BIOSYSTEMATICS-I	4	40	60

Objective	The major objectives of this paper are to acquire depth knowledge about classification and nomenclature of plants, floristic inventory, herbarium techniques and taxonomy of cultivated plants.
Pre-Requisites	Basic knowledge about Plant taxonomy
Teaching Scheme	Regular classroom teaching with localplant identification in laboratory and field.

Detailed Syllabus

Unit	Topics	Hours
I	Synthetic Plant Classification: Characters of taxonomic significance, morphological, anatomical, embryological, palynological and cytological data for developing synthetic approach to classification.	10
II	Plant Nomenclature: Development of ICN, Determination of types and typification. Orthography of names and Epithetes. Principles of priority and its limitation. Names of Hybrids.	9
III	Floristic Survey: Field collection and preservation of specimens. Phytogeography, assessment of threatened species. Analysis of flora of Odisha. Documentation on data. Mangroves of Odisha, significance and conservation.	9
IV	Herbarium management: Concept, historical development. Role of Herbarium, Preservation of specimens and maintenance. Taxonomy of cultivated plants: Centres of diversity and Centres of origin. Exploration and collection of plant genetic resources. Establishment of gene bank. Cryopreservation.	10
V	Ethnobotany and Folk medicines. Definition; Ethnobotany in India: Methods to study ethnobotany; Applications of Ethnobotany: National interacts, Palaeo-ethnobotany. folk medicines of ethnobotany, ethnomedicine, ethnoecology, ethnic communities of India. Application of natural products to certain diseases-Jaundice, cardiac, infertility, diabetics, Blood pressure and skin diseases.	10
	Total	48

ELECTIVE – II (BIOSYSTEMATICS)

Subject Code	Subject Name	Credit	Internal Mark	End Term Mark
BOT-542-B	BIOSYSTEMATICS-II	4	40	60

Objective	The primary objective of this paper is to acquire depth knowledge about classification of plants on the basis of chemical compounds present inside plants, their molecular biology and distribution pattern of plants on earth. The secondary objective of this paper is to familiar with botanical publications, collections and documentation of taxonomic characters.
Pre-Requisites	Basic knowledge about Plant taxonomy
Teaching Scheme	Regular classroom teaching with practical demonstration in laboratory.

Detailed Syllabus

Unit	Topics	Hours
I	Chemotaxonomy: compounds useful in Plant Taxonomy. Primary and secondary metabolites. Semantides. Stages of chemotaxonomic investigation. Genetic techniques in systematics: Genetic analysis of characters and phonetic variation. Dominance, epistasis, pleotropy. Application of DNA hybridization technique in taxonomy.	8
II	Molecular Taxonomy: Application of Molecular markers, Isozyme, RAPD, AFLP, RFLP for phylogeny and establishment of genomic relationship. Resolving taxonomic problems using molecular tools. Assessment of genetic diversity.	9
III	Phytogeography and Taxonomy: Taxonomic information from plant geography and ecology. Patterns of phytogeography. Disjunction. Variance. Endemism, Ecotypification, alien species, phenotypic plasticity.	9
IV	Taxonomic literature: Floras, Monographs and Revisions. Keys: Single access and Multi-access. Use of computers in Taxonomy, collecting and converting data.	12
V	Introduction: Centres of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self pollinated, cross pollinated and vegetatively propagated plants; Hybridization: For self, cross and vegetatively propagated plants Procedure, advantages and limitations.	10
	Total	48

Text Books:

1. Current concepts in plant taxonomy by V.H. Heywood and D. N. Moore.
2. Taxonomy of Angiosperms by AVSS Sambamurthy
3. Plant Taxonomy by O.P. Sharma

   Vascular Plant Taxonomy by Dirk R. Walters

Sub. Code	Paper Name	Credit	Internal Mark	End Term Mark
BOT-543-B	Practical	8	00	100 Experiment : 70 Marks, Practical Record: 10 Marks Viva-Voce: 20 Marks

Biosystematics Practical related to Paper BOT-541-B, 542-B

1. Description of a specimen from representative and locally available families.
2. Description of a species based on various specimens to study intraspecific variation: A collective exercise.
3. Description of various species of a genus: Location of key character and preparation of keys at genetic level.
4. Location of key characters and use of keys at family level.
5. Exercises on nomenclature problems: Author citation, Principle of priority and Transfer of taxa.
6. Field trips within and around the campus; compilation of field notes and preparation of herbarium sheets of such plants wild or cultivated, as are abundant.
7. Comparative study of the pollen grains, fruit and seed morphology.
8. Study of different types of ovules, placentation and evolutionary trends therein
9. Demonstration of the utility of secondary metabolites in the taxonomy of some appropriate genera.
10. Training in using floras and herbaria for identification of specimens.

Sub. Code	Paper Name	Credit	Internal Mark	End Term Mark
BOT-544	Dissertation Work	10	00	200 Rationale and quality of project work:100 Marks (based on the presentation) Dissertation Report : 60 Marks Viva-Voce : 40 Marks

Objectives	To enable to the students design and execute a small research project.
Pre-Requisites	Through understanding about the laboratory and field techniques taught during all the semesters of the course.
Teaching Scheme	At the beginning of the Third semester, the student will select a topic for project work in consultation with teacher assigned to him/her by the department. The student will carry out the project work, and will compile the findings in the form of a project report which will be submitted to the Department. For evaluation, the student will present and defend his/her findings before a Board of Examiners constituting the respective Teacher Supervisor and one External Examiner. Basing on the rationale and quality of project work done, project report and performance in the presentation (Viva-Voce), the Board will award the mark.