



**Syllabus for 4 Year Under Graduate Degree in Botany
Major (Both Hon and Hon with Research) for the
affiliated colleges under the
Cooch Behar Panchanan Barma University,
Cooch Behar**

Based on the guideline of 4YUGP 2023

4 Year Under Graduate Degree (Honours and Honours with Research) in Botany

As per the guideline of the 4-year undergraduate degree (Honours and Honours with Research) program, a new curriculum has been formulated for 4 years under graduate course in botany for the affiliated colleges under the Cooch Behar Panchanan Barma University.

Program Objective:

According to this curriculum, the 1st year course containing two semesters have been proposed. The 1stSEM will have one Major and one Minor course with one MDC and SEC. A course AEC is a compulsory course for undergraduate students. The new curriculum offers essential knowledge and technical skills to the students to study the plants in a comprehensive way. Students will gain the knowledge in all spheres of plant science using core and advance components of the subject. Students will have the exposure to the upgraded new generation technologies that are currently used in the field of plant science. In that way, they will gain plethora of knowledge in the subject itself and its implication in environmental and social perspective.

This course covers both classroom and practical sessions. The students will be engaged in participatory and interactive activities. Candidates with curiosity in plants kingdom and environment and love in exploring exotic places as well as wish to work as researchers or professions like Botanist, Conservationist etc. can choose B.Sc. Botany course.

Scheme and distribution of credits for 4 Year Under Graduate Degree (Honours and Honours with Research) in Botany: Theory: 4 Credit; Practical: 2 Credit.

Scheme and distribution of marks for 4 Year Under Graduate Degree (Honours and Honours with Research) in Botany: Theory: 50 marks; Practical: 25 marks. Internal Assessment: 20 marks; Attendance: 5 marks. (For further details and clarification, please go to the university website to UG NCCF Regulation)

Syllabus Structure of Botany (Major) based on 4YUGP 2023

(Hon with Research):

Year	Semester	Major	Topics
1 st	I	Major 1	Economic Botany and Ethnomedicine
	II	Major 2	Ecology and Phytogeography
2 nd	III	Major 3	Phycology and Lichenology
		Major 4	Mycology and Phytopathology
	IV	Major 5	Bryology and Pteridology
		Major 6	Study of Gymnosperms and Paleobotany
3 rd	V	Major 7	Plant Morphology and anatomy
		Major 8	Systematics of Angiosperms
		Major 9	Plant Physiology
	VI	Major 10	Plant biochemistry
		Major 11	Cell Biology and Genetics
		Major 12	Microbiology
4 th	VII	Major 13	Research Methodologies and Ethics
		Major 14	Elective related to Major discipline*.
		Major 15	Plant biotechnology & Tissue culture
		Major 16	Dissertation
	VIII	Major 17	Laboratory Techniques and Instrumentations
		Major 18	Elective related to Major discipline#.
		Major 19	Dissertation

***A baskets of elective subjects for Major 14 Semester VII: A.** Bio-resource Management, Applied Botany and Evolution, **B.** Microbial Biotechnology. (Students will select any one topic from the basket).

#A baskets of elective subjects for Major 18 Semester VIII: A. Pharmacognosy, **B.** Molecular Biology, **C.** Plant breeding, biostatistics and bioinformatics. (Students will select any one topic from the basket).

Syllabus Structure of Botany (Minor) based on 4YUGP 2023

Year	Semester	Minor	Topics
1 st	I		
	II		
2 nd	III	Minor 3	Phycology, Mycology and Plant Pathology, Bryology Pteridology, Study of Gymnosperms and Paleobotany
	IV	Minor 4	Taxonomy of Angiosperm, Ecology and Environment, Plant Morphology, Anatomy and Economic Botany.
4 th	VII		
	VIII	Minor 6	Plant Physiology and Plant Biochemistry, Cell Biology, Genetics. Plant biotechnology, Microbiology and Plant Breeding.

Syllabus Structure of Botany (Major) based on 4YUGP 2023 (Hon):

Year	Semester	Major	Topics
1 st	I	Major 1	Economic Botany and Ethnomedicine
	II	Major 2	Ecology and Phytogeography
2 nd	III	Major 3	Phycology and Lichenology
		Major 4	Mycology and Phytopathology
	IV	Major 5	Bryology and Pteridology
		Major 6	Study of Gymnosperms and Paleobotany
3 rd	V	Major 7	Plant Morphology and anatomy
		Major 8	Systematics of Angiosperms
		Major 9	Plant Physiology
	VI	Major 10	Plant biochemistry
		Major 11	Cell Biology and Genetics
		Major 12	Microbiology
4 th	VII	Major 13	Research Methodologies and Ethics
		Major 14	Elective related to Major discipline*.
		Major 15	Plant biotechnology & Tissue culture
		Major 16	Pharmacognosy
	VIII	Major 17	Laboratory Techniques and Instrumentations
		Major 18	Elective related to Major discipline#.
		Major 19	Molecular Biology

Honours Program: Semester VII - Major 13, Major 14, Major 15, Major 16; Semester VIII – Major 17, Major – 18, Major – 19.

Honours Program with Research: Semester VII - Major 13, Major 14, Major 15, Major 16; Semester VIII – Major 17, Major – 18, Major – 19.

“Plant Biotechnology and Tissue Culture” is treated as Theory of Major 15 and the topic hence forth is removed from ‘Basket’. Distribution of marks for Major 16 and Major 19 in Honours with Research are as follows: Dissertation: 75 marks (Written 50 and Presentation and viva voce 25); Internal assessment 25 (Attendance 05; Continuous evaluation: 20).

For 4 Year degree with Honours; Major 16 will be Pharmacognosy and Major 19 will be Molecular Biology.

***A baskets of elective subjects for Major 14 Semester VII:** A. Bio-resource Management, Applied Botany and Evolution, (Students will select any one topic from the basket).

#A baskets of elective subjects for Major 18 Semester VIII: A. Microbial Biotechnology, B. Plant breeding, biostatistics and bioinformatics. (Students will select any one topic from the basket).

For 4 Year degree with Honours with Research; Major 16 and Major 19 will be dissertation paper

***A baskets of elective subjects for Major 14 Semester VII:** A. Bio-resource Management, Applied Botany and Evolution; B. Microbial Biotechnology (Students will select any one topic from the basket).

#A baskets of elective subjects for Major 18 Semester VIII: A. Plant breeding, biostatistics and bioinformatics, B. Molecular Biology (Students will select any one topic from the basket).

Course: Theory Syllabus of Major 1

Paper Name: Economic Botany and Ethnomedicine

Paper Code: BOT-MAJ1

Program Objective:

The Major 1 offers essential knowledge and technical skills to the students to study the Economic Botany and Ethnomedicine. This paper deals with economic as well as medicinal importance of plants in a comprehensive way. This course covers both classroom and practical sessions. The students will be engaged in participatory and interactive activities.

Program Outcome: After the completion of the course the students will be able to understand on the origin of the cultivated plants across the globe., gather botanical knowledge of different types of fruits, i.e cereals, pulses, vegetables, fruits, spices etc, understand about some plants yielding drugs, timber, fibre, rubber, beverages, etc. The students will have a preliminary knowledge of economic plants and also have the general idea about ethno medicine and familiarize with some of the important medicinal plants of the region that is North Bengal.

Origin of Cultivated Plants: Vavilov's Concept of Centers of Origin of cultivated crop plants and its importance. Introduction, domestication, evolution of new crop varieties of rice, wheat and potato. Importance of germplasm and loss of genetic diversity.

Cereals: Wheat and Rice (morphology, processing & uses); Brief account of millets cultivated in India.

Legumes: Morphology and uses of Chickpea, Pigeon pea and fodder legumes. Importance to man and ecosystem.

Sources of sugars and starches: Morphology and processing of sugarcane, products and by-products of sugarcane industry. Potato – morphology, propagation & uses.

Spices: Listing of important spices, their family and part used. Economic importance with special reference to fennel, large cardamom, clove and black pepper.

Beverages: Tea (morphology, general processing of black tea and green tea (morphology, general processing and uses)

Sources of oils and fats: General description, classification, extraction, their & uses) Coffee uses and health implications of groundnut, coconut, soybean, mustard (Botanical name, family & uses).

Citronella and Eucalyptus Oils: General account, extraction methods, comparison with fatty oils & their uses.

Natural Rubber: Para-rubber (tapping, processing and uses).

Drug and narcotics yielding plants: Therapeutic and habit-forming drugs with special reference to *Cinchona*, *Digitalis*, *Papaver*, *Cannabis*; Tobacco (Morphology, processing, uses and health hazards).

Timber plants: General account with special reference to Teak and Sal.

Fiber yielding plants: Jute (Morphology, retting of fiber and uses).

Vegetables: Okra, Cabbage. (Cultivation methods)

Fruits: Mango, Orange. (Varieties, fruit quality)

Flowers: Marigold and Tube rose. (Cultivation methods).

Ethnomedicine: Definition; Importance of Ethnomedicine in India..

Scientific name, family, parts used and uses of Plants used by ethnic people of North Bengal:

Eclipta prostrata; *Sesbania grandiflora*; *Glycosmis arborea*; *Vitex negundo*; *Coccinia grandis* (=indica); *Alstonia scholaris*, *Artemisia vulgaris*. *Andrographis paniculata*, *Centella asiatica*, *Rauwolfia serpentina*, *Oroxylum indicum*, *Terminalia spp*, *Ocimum sanctum*, *Justicia adhatoda*

Suggested Readings:

1. College Botany Vol. –I, II & III. - Gangulee and Kar, New Central Book Agency, Kolkata.
2. Studies in Botany, Vol. I. and II - Mitra, Mitra, Choudhury. Moulik Library, Kolkata.
3. Text Book of Botany, Vol.-1 and 2, By Hait, Ghosh and Bhattacharya, New Central Book Agency.
4. Botany – A. C. Datta, Oxford Univ. Press.
5. Economic Botany. B P Pandey. S. Chand Publishing. New Delhi
6. Modern Practical Botany Vol-I, II. B P Pandey. S. Chand Publishing. New Delhi
7. College Botany Vol. I, II, III. B. P. Pandey. S. Chand Publishing. New Delhi
8. College Botany Practical Vol- I, II. S.C Santra, T.P. Chatterjee and A.P. Das; New Central Book Agency, Kolkata.

Course: Practical Syllabus of Major 1

Paper Name: Economic Botany and Ethnomedicine

Paper Code: BOT-MAJ1

Habit sketch of plants included in theory syllabus.

Microscopic study of starch grains and fiber included in theory syllabus.

Excursion (Local and outstation, mandatory for each student) and Submission of dry specimen.

Course: Theory Syllabus of Major 2

Paper Name: Ecology and Phyto-geography

Paper Code: BOT-MAJ2

Program Objective:

The Major 2 offers essential knowledge and technical skills to the students to study the Ecology and Phyto-geography. This course covers both classroom and practical sessions. The students will be engaged in participatory and interactive activities.

Program Outcome: After the completion of the course the students will imbibe concept of ecological concept on the botanical aspect. They will also have knowledge on population study as well as the phytogeography of Eastern Himalaya in particular and general principle of phytogeographical study will be thoroughly conceptualized.

Ecology:

Introduction: Basic concepts; Levels of organization. Inter-relationships between the living world and the environment, Biotic and abiotic components and their dynamism, homeostasis. BOD and COD.

Biotic interactions: Trophic organization, basic source of energy, autotrophy, heterotrophy; symbiosis, commensalism, parasitism; food chains and webs; ecological pyramids; biomass, standing crop.

Habitat and niche: Definition, Concept of habitat and niche; niche width and overlap, fundamental and realized niche; Characters displacement; analytical and synthetic; Ecotone and edge effect; ecological amplitude.

Ecosystems: Structure; Processes (aquatic, grass land and forest).

Adaptations: Adaptations in hydrophytes, halophytes and xerophytes.

Dynamics and Succession: Processes, types; climax concepts.

Functional aspects of ecosystem: Principles and models of energy flow; Production and productivity; Ecological efficiencies; Biogeochemical cycles; Cycling of Carbon, Nitrogen and Phosphorus.

Biogeochemical cycles: Cycling of carbon, nitrogen and phosphorous.

Population ecology: Characteristics and Dynamics. Ecological Speciation.

Phyto-geography: Principles; Continental drift; Theory of tolerance; Endemism; Brief description of major terrestrial biomes (one each from tropical, temperate & tundra); Phytogeographical division of India. Vegetation of Eastern Himalaya.

Course: Practical Syllabus of Major 2

Paper Name: Ecology and Phyto-geography

Paper Code: BOT-MAJ2

Ecology and Phyto-geography: Determination of dissolved oxygen (O₂) and carbon di oxide (CO₂) of water samples from polluted and unpolluted sources.

Study of morphological adaptations of hydrophytes and xerophytes (four each).

Study of biotic interactions of the following: Stem parasite (*Cuscuta*), Root parasite (*Orobanche*) Epiphytes.

Excursion (Local and outstation, mandatory for each student) to familiarize students with ecology of different sites.

To prepare map showing vegetation of West Bengal and to comment on it.

To prepare map of India with respect to – Major Climatic Zones, Biogeographical regions of India and to comment on it.

Suggested Readings:

1. Ecology Environmental Science and conservation. J.S. Singh, S.R. Gupta & S.P. Singh S. Chand Publishing.
2. Environmental Biology (Principles of Ecology). Dr. P S Verma & Dr. V K Agarwal. S. Chand Publishing. New Delhi.
3. A Textbook of Plant Ecology (Including Ethnobotany & Soil Science). P S Chandel & R S Shukla. S. Chand Publishing. New Delhi
4. Ecology and Utility of Plants. P S Chandel & R S Shukla. S. Chand Publishing. New Delhi.
5. College Botany Practical Vol- I, II. S.C Santra, T.P. Chatterjee and A.P. Das; New Central Book Agency, Kolkata.

Course: Theory syllabus of Major 3

Paper Name: Phycology and Lichenology

Paper Code: BOT MAJ3

Program Objective:

The Major 3 offers essential knowledge and technical skills to the students to study the algae and lichens of different habitat. They also will gain the knowledge in habitat, distribution, thallus organization, classification, life cycle patterns as well as origin and evolution of sex in algae. They also gain knowledge of different groups of algae with selected representatives. This paper deals with economic importance of algae as well as lichens in a comprehensive way. This course covers both classroom and practical sessions. The students will be engaged in participatory and interactive activities.

Program Outcome: Gather botanical knowledge of different groups of algae and lichen with preliminary knowledge of economic importance.

Phycology:

General account: Introduction, Habitat and distribution; thallus organization; ultrastructure of algal cell, origin and evolution of sex in algae; Life cycle patterns. Broad outline of classification of Lee (2008) up to class and divisions.

Cyanophyceae: Salient features, ultra-structure of cell, structure and function of heterocyst; reproduction. **Chlorophyceae:** Salient features; life history of *Chlamydomonas*, *Oedogonium* and *Trentepohlia*.

Charophyceae: Salient features; life history of *Coleochate* and *Chara*.

Xanthophyceae: Salient features; life history of *Vaucheria*. **Bacillariophyceae:** Salient features, cell structure and reproduction. **Phaeophyceae:** Salient features; life history of *Ectocarpus*.

Rhodophyceae: Salient features; life history of *Polysiphonia*.

Economic importance: Beneficial: Food and Medicine, diatomaceous earth, development of cyanophycean members as biofertilizer. Harmful: Algae as pathogen in plants and algal toxins. Ecological importance.

Lichenology:

Lichen: Morphological classification, thallus organisation, reproduction; ecological and economic significance.

Course: Practical Syllabus of Major 3
Paper Name: Phycology and Lichenology
Paper Code: BOT-MAJ3L

Details of compound microscope.

Study of the following genera: Preparation of semi permanent slides of *Oscillatoria*, *Oedogonium*, *Chara*, *Vaucheria*, *Polysiphonia* and *Ectocarpus*. The preparation to be stained with cotton blue and drawing of reproductive structures with proper magnification using camera lucida.

Identification of all the genera included in the theoretical syllabus by their vegetative and reproductive structures from permanent slides.

Anatomical and Morphological study of *Parmelia* sp. and *Ramalina* sp.

Field study (Compulsory); Collection of algal members and lichen (photograph only) from the both aquatic bodies as well as terrestrial environments nearby the campus is mandatory for each student.

Suggested Readings:

1. College Botany Vol. –II. - Gangulee and Kar, New Central Book Agency, Kolkata.
2. Studies in Botany, Vol. I. - Mitra, Mitra, Choudhury. Moulik Library, Kolkata.
3. Text Book of Botany, Vol-1 and 2, By Hait, Ghosh and Bhattacharya, New Central Book Agency.
4. Botany – A. C. Datta, Oxford Univ. Press.
5. The structure and reproduction of algae, Fritsch, F. E. Vol. I (1935), Vol. II. Cambridge University Press
6. Introduction to the algae: structure and reproduction. 3rd Edition (1985). Bold, H. C. and Wynne,
7. M. J. Wall. Prentice Hall of India Private Limited.
8. Phycology. 4th edition. Lee, R. E. (2009) Cambridge University Press.
9. An Introduction to Phycology. Van der Hock, D. G. Mann and Johns, H. M. 1995. Cambridge University Press.
10. Text Book of Algae, Sharma O.P. Tata McGraw Hill Publishing Co. Latest edn.
11. Botany for degree students. Algae. B. R. Vashistha, A. K. Sinha. V. R. Singha (Latest edition).

Course: Theory syllabus of Major 4
Paper Name: Mycology and Phytopathology
Paper Code: BOT MAJ4

Program Objective:

The Major 4 offers essential knowledge and technical skills to the students to study the fungi and phytopathology. They also will gain the knowledge in fungal tissue organization, modification of hyphae, structure of fungal cell, flagella, habit, septum, homothallism and heterothallism, parasexuality, cell division of fungi of different groups of fungi with selected representatives. This paper deals with economic importance of fungi in a comprehensive way. Cultivation of mushroom is also taught.

This paper also deals with plant diseases, its definition; concepts of parasitism and saprophytism, Koch's postulate, classification of plant diseases, pathotoxins, structural and biochemical defense mechanism of plants, control of Plant diseases, symptoms, disease cycles and control measures selected plant diseases. This course covers both classroom and practical sessions. The students will be engaged in participatory and interactive activities.

Program Outcome: Gather botanical knowledge of different groups of fungi and plant pathology with preliminary knowledge of economic importance.

Mycology:

Introduction, Salient features, fungal tissue organization, modification of hyphae, structure of fungal cell, flagella, habit, septum, homothallism and heterothallism, parasexuality, cell division. Broad outline of Classification of Ainsworth and Bisby (1983).

Phycomycetes: Salient features life histories of *Synchytrium*, *Rhizopus*.

Ascomycetes: Salient features, ascus development, types of ascocarps; life histories of *Saccharomyces* and *Ascobolus*.

Basidiomycetes: Salient features (Dikaryotization, Clamp connection); development of Basidium (holobasidium and phragmobasidium), fruit body types, life histories of *Puccinia*, *Agaricus* and *Polyporus*.

Deuteromycetes: Salient features with special reference to conidial fruit body types. Economic importance of fungi – Both beneficial and harmful aspects.

Fungi as food: Mushroom – types; procedure of spawn production and cultivation of Oyster and Button mushroom.

Mycorrhiza: Mycorrhizal diversity & association and its applications in agriculture and forest-

ry.

Phytopathology:

Terminology: Etiology and causal complex, symptoms and signs, infection, inoculum, primary and secondary inoculum, inoculum potential, pathogenecity and pathogenesis, necrotroph and biotroph, epidemic disease, endemic disease, sporadic disease, disease triangle and disease cycle.

Diseases: Definition; concepts of parasitism and saprophytism, Koch's postulate. Classification of plant diseases based on symptoms. Pathotoxins- definition and general account. Structural and biochemical defense mechanism of plants. Control of Plant diseases: Physical, chemical and biological methods. Symptoms, disease cycles and control measures of White rust of crucifer, Brown spot of rice, Late blight of potato and Rust of wheat.

Course: Practical Syllabus of Major 4

Paper Name: Mycology and Phytopathology

Paper Code: BOT MAJ4L

Mycology:

Standardization techniques using ocular and stage micrometer.

Study of the following genera: Preparation of semi-permanent slides of *Rhizopus*, *Ascobolus*, *Agaricus* and *Polyporus*. The preparation to be stained with cotton blue and drawing and measurement of reproductive structures.

Identification of all the macroscopic and microscopic genera included in the theoretical syllabus. Study of mycorrhizal association with roots.

Phytopathology:

Study of the following diseases: White rust of crucifers, black Rust of wheat/*Justicia*, loose smut of wheat (or any member of Poaceae), late blight of potato, brown spot of rice and blister blight of tea.

Preparation of PDA media and isolation of pathogen from infected plant parts. Sub-culturing of fungi. Spawn preparation of Oyster mushroom.

Field study: Botanical excursion is mandatory for each student. Symptomatic study of Viral, Bacterial and Fungal diseases of crop plants and submission of dry specimens/ Photographs is mandatory for each student.

Suggested Readings:

1. Introduction to Fungi. Webster, J. Cambridge University Press.
2. Introduction to Fungi, Dubey, H. C. Vikas Publishing House.
3. Introduction to Mycology. Alexopoulos, C. J., Mims, C. W. and Blackwell Wiley. Eastern Limited, New Delhi.
4. Introductory Mycology. R. S. Mehrotra and Aneja, K. R. New Age International
5. Text Book of Fungi, Sharma, O. P. Tata Mc Graw Hill Publishing Co. Latest edn.
6. Botany for degree students. Fungi. B. R. Vashistha, A. K. Sinha. V. R. Singha (Latest edition). S. Chand
7. Plant Pathology. Agrios R. N. academic Press 18. Plant Pathology, Mehrotra, R. S. Tata Mc Graw Hill Publishing Company. New Delhi
8. Diseases of Crop Plants in India. Rangaswamy, G. Prentice Hall India Pvt. Ltd. New Delhi
9. Plant Diseases. Singh, R. S. Oxford & IBH, New Delhi.
10. Pathogen and Plant Diseases. Pandey, B. P., S. Chand & Company Ltd. Rangaswamy, G. New Delhi

Course: Theory Syllabus of Major 5**Paper Name: Bryology and Pteridology****Paper Code: BOT-MAJ5****Program Objective:**

The Major 5 offers essential knowledge and technical skills to the students to study the bryophytes and pteridophytes. They also will gain the knowledge in adaptations to land habit, colonization and rise of

early land plants, origin of bryophytes and pteridophytes, telome concept and its significance, enation theory and its significance, amphibian nature of bryophytes, apogamy, apospory, parthenogenesis; heterospory and seed habit, stellar evolution in pteridophytes. Morphology, anatomy and reproduction of selective members of bryophytes and pteridophytes will be studied.

This course covers both classroom and practical sessions. The students will be engaged in participatory and interactive activities.

Program Outcome: Gather botanical knowledge of different groups of bryophytes and pteridophytes with preliminary knowledge of economic importance.

Bryology:

Introduction, general characteristics and adaptations to land habit, salient features of Hepaticopsida, Anthocerotopsida and Bryopsida. Origin of Bryophytes. Amphibian nature of Bryophytes. Broad outline of Classification according to Crandell-Stotler and Stotler (2008). Life histories of *Riccia*, *Marchantia*, *Anthoceros*, *Sphagnum* and *Funaria*.

Origin of alternation of generations in Bryophytes (Homologous and Antithetic theory). Evolution of Sporophytes in Bryophytes (Progressive and Regressive concept).

Role of Bryophytes in plant succession, pollution monitoring. Economic importance of Bryophytes with special reference to *Sphagnum*.

Pteridology:

Introduction, general characteristics, Salient features of Psilophyta, Lycophytagy, Sphenophyta and Filicophyta.. System of classification up to Division (Gifford & Foster, 1989).

Morphology, anatomy and reproduction of *Rhynia*, *Psilotum*, *Lycopodium*, *Selaginella*, *Equisetum*, *Marsilea* and *Pteris*.

Colonization and rise of early land plants. Telome concept and its significance in the origin of different groups of Pteridophytes. Enation theory and its significance in the origin of microphyll. Apogamy, apospory, parthenogenesis; heterospory and seed habit, stelar evolution in pteridophytes. Ecological and economic importance of Pteridophytes.

Course: Practical Syllabus Major 5**Paper Name: Bryology and Pteridoogy****Paper Code: BOT-MAJ5L****Bryology and Pteridology**

Study of the gametophytic and sporophytic structures of the following genera: *Riccia*, *Marchantia*, *Anthoceros* and *Funaria*. Spot identification of genera that are included in the theoretical syllabus. The bryophytes preferably to be stained with Bismarck Brown Staining (Single staining)

Study of morphology, anatomy and reproductive structures in *Lycopodium*, *Selaginella*, *Equisetum*, *Marsilea* and *Pteris*. Spot identification of the genera that are included in the theoretical syllabus. The non lignified tissue to be stained with Bismarck Brown Staining (Single staining) while lignified tissues are to be stained with Double staining method (preferably

with Safranin and Fast Green Staining).

Field Study: Botanical excursion is (local and / or outstation) mandatory for each student. A field notebook supported with photographs taken during field study to be submitted giving comprehensive idea about different types of bryophytes and pteridophytes. No individual collection should be allowed (submission of dry and wet specimens is not required).

Preparation of digital herbarium.

Suggested Readings:

1. Biology of Bryophytes, 2005, Chopra, R. N. & P. K. Kumra, New Age International, New Delhi.
2. Bryophyte Biology (2nd Edition), 2009, Gofnet, B. & A. J. Shaw, Cambridge University Press.
3. Parihar, N.S. Introduction to Embryophyta (Vol. 1 Bryophyta), Central Book Distributors.
4. Shaw, A. Jonathan and Goffinet Bernard, Bryophyte Biology, 2009, Cambridge University Press.
5. Rashid, A. An Introduction to Bryophyta, 1998, Vikas Publishing House.
6. Chopra, R.N. & Kumar, P.K. Biology of Bryophyta, Latest Ed., Wiley Eastern.
7. Puri, P. Bryophyte, Latest Ed., Atmaram & Sons.
8. Vashista, B.R. Bryophyta, Latest Ed., S. Chand & Company.
9. Spore, K.R. The Morphology of Pteridophyte, Latest Ed., Huchinson & Co. Ltd.
10. Rashid, A. An Introduction to Pteridophyte, Latest Ed., Vani Educational Books.
11. Vashistha, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. S. Chand. Delhi, India.
12. Morphology of Vascular Plants – Lower Groups. 1936. Eames, A. J. Tata McGraw Hill, New Delhi.
13. Morphology and Evolution of Vascular Plants. 1989. Gifford E.M and Foster A.S W H
14. Freeman and Company, New York.
15. Hait, G., Ghosh, A. and Bhattacharya, K. A Text Book of Botany (Vols. I, II & III), 2007, New Central Book Agency.
16. Mitra, D., Guha, J. & Chowdhuri, S.K. Studies in Botany (Vols. I & II), Latest Ed., Das Printers.
17. Chatterjee, T., Santra, S.C. and Das, A. Practical College Botany, New Central Book Agency.

Course: Theory syllabus for Major 6

Paper Name: Gymnosperms, Palaeobotany & Palynology.

Paper code: BOT-MAJ6

Program Objective:

The Major 6 offers essential knowledge and technical skills to the students to study the The Major 6 offers essential knowledge and technical skills to the students to study the Palaeobotany and Gymnosperms and Palynology. They also will gain the knowledge in classification, evolutionary trends in Gymnosperm as well as affinities with Pteridophytes and Angiosperms. Morphology, anatomy and reproduction of selective members of gymnosperms will be studied.

In paleobotany, major events of plant life fossilizations process, types of fossil and dating of fossils is discussed. Fundamentals of palaeogeography, palaeoecology and palaeoclimatology also studied In paleobotany, major events of plant life through geological time scale, Gondwana flora, fossil formation, sil and dating of fossils is discussed. Fundamentals of palaeogeography, also studied. The basic ideas of palynology are also discussed in this paper.

Program Outcome: Gather botanical knowledge of different groups of gymnosperms as well as basic ideas of fossils, fossilization and fossil flora as well as preliminary knowledge of palynology.

Gymnosperms:

Characteristic features and classification of Gymnosperms (Bhatnagar & Moitra (1996) up to orders. Evolutionary trends in Gymnosperm, affinities with Pteridophytes and Angiosperms, Morphology, reproduction and life cycle and economic importance of *Cycas*, *Pinus*, *Gnetum*, *Ephedra* and *Ginkgo*.

Polyembryony and pollination drop with special reference to *Pinus*. Economic importance of Gymnosperms. (Wood, resin, essential oil & drugs). Ecological importance of Gymnosperms (Avenue Trees, soil allelopathy)

Palaeobotany:

In paleobotany, major events of plant life fossilizations process, types of fossil and dating of fossils is discussed. Fundamentals of palaeogeography, palaeoecology and palaeoclimatology also studied. In paleobotany, major events of plant life through geological time scale, Gondwana flora, fossil formation, types of fossil and dating of fossils is discussed. Fundamentals of palaeogeography also studied.

Palynology:

Definition, scope and economic importance. NPC classification. Pollen morphology, Melissopalynology

Course: Practical syllabus of Major 6

Paper name: Gymnosperms, Palaeobotany & Palynology

Paper code: BOT-MAJ6L

Study of morphology, anatomy and reproductive structure of *Cycas*, *Pinus*, *Gnetum* and *Ephedra*, through temporary and permanent slides.

Lignified tissues are to be stained with Double staining method (preferably with Safranin and Fast Green Staining).

Study of anatomy and modes of preservation of the following fossil specimen: (a) *Lepidodendron* (T.S. of stem) (b) *Calamites* (T.S. of stem) (c) *Lyginopteris* (T.S. of stem). (d) *Lepidodendron* (seed) (e) *Glossopteris* (leaf) (f) *Vertebraria* (Root).

Melissopalynological studies of local honey samples. Study of pollen morphology of *Datura* / *Hibiscus*.

Field Study: Botanical excursion (Local and /out station mandatory), submission of field note book, field photographs of collected specimen is required.

Preparation of digital herbarium.

Suggested Readings:

1. Bhatnagar, S.P & Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
2. Ganguly H.C & Kar A.K. College Botany, Volume II. (Latest edition) New Central Book Agency, Kolkata, India.
3. Mitra J.N, Mitra D & Chaudhari S.K, Studies in Botany, Volume I (Latest edition), Moulik Library, Kolkata, India.
4. Vashishtha P.C, Sinha A.K & Kumar Anil, Botany for degree students-Gymnosperms (Latest edition), S.Chand, Delhi, India.
5. Johri B.M & Biswas C. The Gymnosperms, Springer.
6. K.U Kramer & Green P.S, The Families and Genera of Vascular plants Pteridophytes and Gymnosperms (Latest edition), Springer.
7. Stewart W.N & Rathwell G.W, Palaeobotany and the Evolution of Plants. (Latest edition), Cambridge University Press.
8. Taylor Thomas N, Taylor Edith L. & Krings Michael, Palaeobotany - The Biology and Evolution

of Fossil Plants (Latest edition), Academic press, Elsevier.

9. Mishra S.R. Textbook of Palaeobotany (Latest edition), Discovery Publishing House. Discovery Publishing House.

10. Kashinath Bhattacharya Textbook of Palynology (Latest edition) by, New Central Book Agency Publications.

11. Chatterjee, T., Santra, S.C. and Das, A. Practical College Botany, New Central Book Agency.

Course: Theory syllabus of Major7

Paper Name: Plant Morphology and Anatomy

Paper Code: BOT MAJ 7

Program Objective: The Major 7 offers essential knowledge and technical skills to the students to study the Plant Morphology and Anatomy and The paper offers essential knowledge and technical skills to the students to study this subject. They also will gain the knowledge in plant tissue organization, modification of plant tissue and structure of plant cells and organs.

Program Outcome: Gather botanical knowledge of different morphology of plants and plant anatomy with preliminary ideas.

Plant Morphology: Leaf: Definition; Different parts, types and example; Margin, Apex, Surface, Base and Texture of Lamina: Different types and example; Stipule: Different types with modifications and examples; Venation: Different types and example; Phyllotaxy: Different types and example; ligule and auricle; modifications of leaves.

Roots: Definition, Types, functions and characteristics; Different parts of root; Modifications of roots.

Stem: Definition; Types, functions and characteristics; Different forms of stem; Surface and nature of stem, Modifications of stem; Branching: types.

Homology and Analogy: Concept and its role in plant function with special reference to defense mechanism.

Inflorescence: Definition and different types with examples.

Flower: Concept of flower; Types, Parts of a flower and their modifications, appendages and forms (whichever is applicable); Flower as a modified shoot; Insertion of floral leaves on thalamus; Aestivation: types with examples; Androecium: attachment of anther to the filaments, Dehiscence of anther, relative length of the filament; Gynoecium: types, parts of

carpels, Placenta and Placentation: types with examples; floral formulae, floral diagram; adhesion and cohesion of floral parts. Ovule: Definition, structure types with example.

Pollination: Types and contrivances. Advantages and disadvantages of self and cross pollination.

Sporogenesis and Gametogenesis: Microsporogenesis; microgametogenesis; megasporogenesis; Megagametogenesis or formation of embryo sac; Development of different types of embryo sacs.

Fertilization: Definition; process; Post fertilization changes: development and different types of embryo (both monocot and dicots); Endosperm: Definition and development; formation of seed. Apomixis; Polyembryony.

Fruits and Seeds: Definition and types with example. Dispersal of fruits and seeds.

Plant Anatomy:

Cell wall: Origin, ultra-structure, chemical composition, gross microscopic structure and components, growth and thickenings;

Tissue and Tissue system: Definition; organization of shoot and root apices; Theories of structural development and differentiation of meristem; Stomata: types; Lenticel; Mechanical tissues: Types and the principles governing their distribution in plants. Vascular bundle: types; nodal anatomy, Epidermal (multiple epidermis, bulliform cells, trichoblasts, glandular hairs) and ground tissue system (General features of cortex, pith and medullary rays); Stele types and evolution. Root-stem transition. Ergastic matters.

Secondary growth: Normal secondary growth in dicot stem and root; concept of growth ring; ring and diffused porous wood; heart wood and sap wood; Periderm; Cambium: origin, structure and function; bark, phelloderm and rhytidome. Anomalous secondary growth in stems: definition and types with example.

Course: Practical Syllabus of Major 7

Paper Name: Plant Morphology and Anatomy

Paper Code: BOT-MAJ7L

Morphology: 1. Morphological study: As per theoretical syllabus (No Submission is required).

Microscopic identification: As per theoretical syllabus.

Plant Anatomy: Staining: Concept, significance and procedure of single and double staining.

Study of the normal and anomalous growth structures of stems, roots and leaf of the following genera (Double staining): Preparation of permanent slide and study of anatomical fea-

tures of *Nerium* Leaf, Orchid and Arum root, stem of *Zea mays*, *Leonurus/Leucas*, *Cucurbita*, *Helianthus*, *Bignonia*, *Boerhaavia*, *Tinospora*, *Amaranthus* and *Chenopodium*. (Submission of permanent slide from plant specimen is required).

Macroscopic and / or Microscopic study: As per theoretical syllabus.

Field study: Local or out station field study.

Suggested Readings:

1. College Botany Vol. –I, II & III. - Gangulee and Kar, New Central Book Agency, Kolkata.
2. Studies in Botany, Vol. I. and II - Mitra, Mitra, Choudhury. Moulik Library, Kolkata.
3. Text Book of Botany, Vol.-1 and 2, By Hait, Ghosh and Bhattacharya, New Central Book Agency.
4. Botany – A. C. Datta, Oxford Univ. Press.
5. College Botany Vol. I, II, III. B. P. Pandey. S. Chand Publishing.
6. College Botany Practical. Vol- I, II. S.C. Santra, A.P. Das T.P. Chatterjee New Central Book Agency.
7. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.
8. Fahn, A. (1974). Plant Anatomy. Pergmon Press, USA.
9. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.
10. Evert, R.F. (2006) Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function and Development. John Wiley and Sons, Inc. S
11. Plant Anatomy. B. P. Pandey S. Chand Publishing

Course: Theory syllabus of Major 8

Paper Name: Systematics of Angiosperms

Paper Code: BOT MAJ 8

Program Objective:

The Major 8 offers essential knowledge and technical skills to the students to study the Systematics of Angiosperms and it also offers essential knowledge and technical skills to the students to identify plant specimens in field. They also study the theoretical portion of plant taxonomy, herbarium techniques and other fields related to identification and nomenclature of angiospermic plants.

Program Outcome: Gather botanical knowledge of different angiospermic plant species.

Systematics of Angiosperms:

Introduction: Taxonomy and systematic; aim and objectives of systematic botany; important terminologies related to taxonomy; plant identification; units of classification, Nomenclature: generic name, specific epithet, Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary); author citation; concept of key in taxonomy; role of morphology in plant taxonomy.

Principles and rules (ICN): Ranks and names; typification; author citation; effective and valid publication; Rejection of names; principle of priority and its limitations; Naming of hybrids. Principle of nomenclature; Idea of IUCN.

Field inventory: Field and herbarium techniques; functions of Herbarium; Important herbaria and botanical gardens of the world and India; Documentation: Flora, Monographs, Keys: Single access and Multi-access; Digital Herbarium.

Plant Classification: Artificial, natural and phylogenetic system of plant classification; Detail study of important plant classification system with merits and demerits: Bentham and Hooker's system (1862 - 1883), Dicta of Bessey (1915); Takhtajan's system of classification (1969).

Basic understanding: Angiosperm Phylogeny Group (APG IV, 2016) classification and numerical taxonomy; Phenetic, Cladistics, operational Taxonomic unit (OTU).

Study of the following families: Ranunculaceae, Magnoliaceae, Euphorbiaceae, Fabaceae (including sub families), Malvaceae, Tiliaceae Brassicaceae, Solanaceae, Acanthaceae, Verbenaceae, Lamiaceae, Apocynaceae, Asclepiadaceae, Rubiaceae, Cucurbitaceae, Asteraceae, Alismataceae, Arecaceae, Liliaceae, Commelinaceae, Zingiberaceae, Poaceae and Orchidaceae.

Course: Practical Syllabus of Major 8

Paper Name: Systematics of Angiosperms

Paper Code: BOT-MAJ8L

Scheme for description and identification of plants.

Identification of plant material: As per theoretical syllabus (Locally available specimen.)

Field study: Local / out station.

Work out of plant materials: As per theoretical syllabus (Locally available specimen). The plant material will be identified up to genus following "Bengal plants, Vol -1 & 2; David Prain, 1903".

Submission of herbarium: Twenty (20) properly dried, mounted and identified herbarium specimens to be submitted. Endangered plants or garden plants should not be collected. Submissions of twenty herbarium specimen are recommended to preserve biodiversity.

Suggested Readings:

1. Datta, S. C. 1988. Systematic Botany. Wiley Eastern Limited, New Delhi.
2. Naik, V. N. 1984. Taxonomy of Angiosperms. Tata McGraw-Hill Publishing Company Limited, New Delhi.
3. Radford, A. E. 1986. Fundamentals of Plant Systematics. Harper & Row, London.
4. Singh, G. 2012. Plant Systematics – Theory and Practice. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
5. Sivarajan, V. V. 1991. Introduction to the Principles of Plant Taxonomy. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
6. Stace, C. A. 1989. Plant Taxonomy and Biosystematics. Arnold Publishers, United Kingdom.
7. College Botany Vol. –I, II & III. - Gangulee and Kar, New Central Book Agency, Kolkata.
8. Studies in Botany, Vol. I. and II - Mitra, Mitra, Choudhury. Moulik Library, Kolkata.
9. Text Book of Botany, Vol.-1 and 2, By Hait, Ghosh and Bhattacharya, New Central Book Agency.
10. College Botany Vol. I, II, III. B. P. Pandey. S. Chand Publishing.

Course: Theory syllabus of Major 9

Paper Name: Plant Physiology

Paper Code: BOT MAJ 9

Program Objective:

The Major 9 offers essential knowledge and technical skills to the students to study the plant physiology. This paper aims provide students with a foundational understanding of how plants function at physiological and biochemical levels. The purpose of this course is to develop a clear conceptual grasp of vital processes such as water relations, mineral nutrition, photosynthesis, respiration, growth regulation, and plant responses to environmental stress. By integrating theory with hands-on experiments, students will gain practical skills in analyzing plant processes and interpreting physiological data. The course also encourages critical thinking about how plants adapt to changing environments, with an emphasis on climate resilience.

Program Outcome: Gather botanical knowledge of physiology of plants.

Plant Physiology:

Plant-water relations: Water Potential and its components, water absorption by roots aquaporins; Mechanism of water absorption: active and passive, pathway of water movement, symplast, apoplast; Transmembrane pathways; Root pressure; Guttation; Ascent of sap, Cohesion-Tension and transpiration pull theory; Transpiration and factors affecting transpiration; Anti-transpirants; Mechanism of stomatal movement; Translocation in the phloem; Experimental evidence in support of phloem as the site of sugar translocation; Pressure-Flow Model; Phloem loading and unloading; Source-sink relationship.

Mineral nutrition: Essential and beneficial elements; macro and micronutrients; criteria for essentiality; Mineral deficiency symptoms; roles of essential elements; Chelating agents.

Photosynthesis: Concept; role of photosynthetic pigments (chlorophylls and accessory pigments); Antenna molecules and reaction centers; Light harvesting complexes; Photosystem I and II; Electron transport chain and photophosphorylation (cyclic and non-cyclic); Water-splitting complex and photolysis; Z-scheme; Light and Dark reaction; photorespiration; CO_2 fixation - C3, C4 and CAM; Factors affecting photosynthesis.

Carbohydrate metabolism: Interconversion of carbohydrates: sucrose, starch, cellulose metabolism.

Plant Respiration: Glycolysis; Oxidative pentose phosphate pathway; Oxidative decarboxylation of pyruvate: TCA cycle; mitochondrial electron transport; Oxidative phosphorylation; Factors affecting respiration; Alternate oxidase.

Plant growth regulators: Discovery; chemical nature (basic structure); Physiological roles of Auxin, Gibberellins, Cytokinin, Abscissic acid, Ethylene; Brassinosteroids and Jasmonic acid.

Physiology of flowering: Photoperiodism; Flowering stimulus, Florigen concept, Vernalization and seed dormancy.

Sensory photobiology: Concept of Photomorphogenesis, Function of photo sensory pigments (phytochromes, cryptochromes and phototropins), Long Day, Short day, Day Neutral plants, Structure of Phytochrome, photoperiodism and biological clock.

Secondary metabolites: Definition and Significance: Primary vs secondary metabolites; Different classes of Secondary metabolites -Alkaloids, Phenolics, Terpenoids (Elementary idea), functions and their applications.

Stress physiology: Basic Concepts of stress; Strain; Resistance; Types of stress: Biotic and abiotic; general responses: avoidance, tolerance, acclimation, Elementary concept of Oxidative stress.

Course: Practical Syllabus of Major 9

Paper Name: Plant Physiology

Paper Code: BOT-MAJ9L

Experimental demonstration of Hill's reaction.

To study the effect of light intensity on the rate of photosynthesis.

Effect of carbon dioxide on the rate of photosynthesis.

To compare the rate of respiration in different parts of a plant.

Comparison between rate of transpiration, evaporation and guttation.

Determination of Temperature coefficient (Q₁₀) in living tissue.

Determination of Osmotic potential in living tissue through plasmolytic, weighing method.

Determination of stomatal frequency and stomatal index.

Suggested Readings:

1. College Botany Vol. –I, II & III. - Gangulee and Kar, New Central Book Agency, Kolkata.
2. Studies in Botany, Vol. I. and II - Mitra, Mitra, Choudhury. Moulik Library, Kolkata.
3. Text Book of Botany, Vol.-1 and 2, By Hait, Ghosh and Bhattacharya, New Central Book Agency.
4. Botany – A. C. Datta, Oxford Univ. Press.
5. College Botany Vol. I, II, III. B. P. Pandey. S. Chand Publishing.
6. A Text Book of Plant Physiology. S.N. Pandey and B.K. Sinha (2015). Vikas Publishing House Pvt. Ltd.
7. Plant Physiology and Development. Lincoln Taiz, Santa Cruz Eduardo Zeiger Ian Max Møller Angus Murphy.

Course: Theory syllabus of Major 10

Paper Name: Plant Biochemistry

Paper Code: BOT MAJ 10

Program Objective:

The Major 10 offers essential knowledge and technical skills to the students to study the plant biochemistry. This paper aims provide students with a foundational understanding of the biochemical structure and functions of biomolecules and to establish links between biochemical processes and plant physiology. The program has the aim to develop analytical and experimental skills among students through lab-based hands-on learning on the subject. The program is also wants to introduce applied aspects of biochemistry relevant to agriculture, environment, and industry.

Program Outcome: Gather botanical knowledge of plant biochemistry.

Biomolecules: Structure of atoms; molecules and chemical bonds; Types and significance of Stabilizing interactions (van der Waals, electrostatic, hydrogen bonding, hydrophobic interaction, etc.); Structure and properties of water; Concept of pH, Buffer.

Carbohydrates: Nomenclature; Classification and properties of Monosaccharide, Disaccha-

rides Oligosaccharides and Polysaccharides

Lipids: Definition and importance, Classification; Fatty acids - structure and functions, Essential fatty acids, phospholipids, glycolipids, role in membranes.

Proteins: Structure of amino acids, classification, based on charge and polarity, peptide bond: Levels of protein structure-primary, secondary, tertiary and quaternary; Biological role of proteins.

Nucleic acids: Types of nucleic acids; Comparison between structures of A, B, Z types of DNA; Watson and Crick model; Types of RNA; Structure of tRNA and mRNA.

Bioenergetics: Laws of thermodynamics; Concept of free energy, entropy, enthalpy; Endergonic and exergonic reactions.

Enzymes: Basic concept and structure- Holoenzyme, Apoenzyme, Cofactors, Coenzymes, prosthetic group and isozymes; Enzyme classification, Nomenclature, features of active site, substrate specificity, Mechanism of enzyme action (activation energy, lock and key hypothesis, induced-fit theory), Enzyme kinetics (Michaelis-Menten theory), Inhibition, Regulation.

Lipid metabolism: Fatty acid β -oxidation, Triacylglycerol metabolism in seeds, Glyoxylate cycle.

Nitrogen metabolism: Nitrogen uptake: nitrate and ammonium assimilation; Nitrate reduction (NR, NiR), Ammonia assimilation (GS-GOGAT, GDH pathways); Biological nitrogen fixation: (examples of legumes and non-legumes); Ammonia assimilation and transamination.

Course: Practical syllabus of Major 10

Paper Name: Plant Biochemistry

Paper Code: BOT MAJ 10L

Qualitative detection of carbohydrates (non-reducing and reducing); proteins and organic acids (oxalic, citric, tartaric and malic acid) in laboratory sample.

Quantities estimation of (a) proteins by Folin Phenol reagent (colorimetric estimation); (b) glucose by Benedict's quantitative reagent; (c) catalase and urease activity in plant sample. (d) Total titratable acidity from lemon.

Effect of different chemicals on membrane permeability.

Paper chromatographic separation of plant pigments.

Suggested Readings:

1. College Botany Vol. -I, II & III. - Gangulee and Kar, New Central Book Agency, Kolkata.

2. Studies in Botany, Vol. I. and II - Mitra, Mitra, Choudhury. Moulik Library, Kolkata.
3. Text Book of Botany, Vol.-1 and 2, By Hait, Ghosh and Bhattacharya, New Central Book Agency.
4. Lehningers Principal of Biochemistry: International Edition by David L. Nelson and Michael cox.
5. Wilson and Walkers Principles and Techniques of Biochemistry and Molecular Biology. 8th Eds, Cambridge University Press.
6. Fundamentals of Biochemistry by J L Jain, Nitin Jain, Sunjay Jain; S Chand and Co.

Course: Theory syllabus of Major 11

Paper Name: Cell Biology and Genetics

Paper Code: BOT MAJ 11

Program Objective:

The Major 11 offers essential knowledge and technical skills to the students to study the cell biology and genetics and the students also will gain the knowledge in scientific understanding of cell biologists and geneticists working in this particular field in nineteenth and twentieth century. The knowledge in this field paves the path of molecular biology and biotechnology.

Program Outcome: Gather botanical knowledge in cell biology and genetics with preliminary ideas.

Cell Biology:

The cell: Cell theory; Characteristics of prokaryotic and eukaryotic cells; Origin of cell and first organism; Endosymbiotic theory.

Plasma membrane: Overview of membrane function; fluid mosaic model; Chemical composition of membranes; Membrane transport – Passive, active and facilitated transport, endocytosis and exocytosis.

Cell organelles: Nucleus: Structure of nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin; nucleolus. Cytoskeleton: Role and structure of microtubules, microfilaments and intermediary filament. Chloroplast, mitochondria and peroxisomes: Structural organization; Function; Semiautonomous nature of Mitochondria and chloroplast. Endomembrane system: Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER, protein folding, processing; Smooth ER and lipid synthesis, export of proteins and lipids; Golgi Apparatus – organization, protein glycosylation, protein

sorting and export from Golgi Apparatus; Lysosomes

Cell division: Phases of eukaryotic cell cycle, mitosis and meiosis; Regulation of cell cycle-checkpoints, role of protein kinases.

Genetics:

Mendelian genetics and its extension: Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Autosomes and sex chromosomes; Probability and pedigree analysis; Incomplete dominance and codominance; Multiple alleles, Lethal alleles, Epistasis, Pleiotropy, Recessive and Dominant traits, Penetrance and Expressivity, Polygenic inheritance.

Extra chromosomal Inheritance: Characteristic, study of extra chromosomal Inheritance in Variegation in Four o'clock plant; Maternal effects: shell coiling in snail; Infective heredity-Kappa particles in *Paramecium*.

Linkage, crossing over and chromosome mapping: Linkage and crossing over-Cytological basis of crossing over; Recombination frequency, two factor and three factor crosses; Interference and coincidence; Numericals based on gene mapping; Sex Linkage.

Variation in chromosome number and structure: Autopolyploidy and allopolyploidy; Euploidy and Aneuploidy; Deletion, Duplication, Inversion, Translocation; Position effect, evolution of wheat and tobacco.

Gene mutations: Types of mutations; Molecular basis of Mutations; Mutagens – physical and chemical (Base analogs, deaminating, alkylating and intercalating agents); Detection of mutations: ClB method. Role of transposons in mutation. DNA repair mechanisms.

Fine structure of gene: Classical vs molecular concepts of gene; Cis-Trans complementation test for functional allelism.

Population and Evolutionary Genetics: Allele frequencies, Genotype frequencies, Hardy-Weinberg Law, role of natural selection, mutation, genetic drift. Genetic variation and Speciation.

Course: Practical syllabus of Major 11

Paper Name: Cell Biology and Genetics

Paper Code: BOT MAJ 11L

Study of comparative cell structure through micrometry: Bacterial, algal, fungal, animal and plant cell structure. (Bacterial cell – *Lactobacillus* sp from curd sample; algal cell – *Nostoc* and *Oedogonium*; Fungal cell – Yeast and *Rhizopus*; Animal cell – Squamous epithelium; Plant cell – Onion scale leaf and epidermis of *Basella*.)

Counting the cells per unit volume with the help of haemocytometer. (Yeast /pollen grains).

Study the phenomenon of plasmolysis and deplasmolysis.

Study the effect of organic solvent and temperature on membrane permeability.

Study different stages of mitosis, mitotic index and karyotype of *Allium cepa* by aceto-orcein squash technique.

Study of meiosis of *Allium cepa* and *Rhoeo* by aceto-carmin smear technique.

Chi-square tests with seed samples for Mendelian and Non Mendelian ratios.

Chromosome mapping using point test cross data.

Pedigree analysis for dominant and recessive autosomal and sex linked traits.

Incomplete dominance and gene interaction through seed ratios: 9:7; 12:3:1; 9:3:4; 9:6:1; 13:3; 15:1.

Suggested Readings:

1. Cell Biology, Genetics, Evolution & Ecology. by Verma P.S. and Agarwal V.K. S Chand and Co.
2. Cell Biology and Genetics: A text Book for Undergraduate Students. P K Gupta Rastogi Publication, Meerut.
3. Fundamentals of Genetics by Dr. B. D. Singh, Medtech Science Press, Delhi.

Course: Theory syllabus of Major 12

Paper Name: Microbiology

Paper Code: BOT MAJ 12

Program Objective:

The Major 12 offers essential knowledge and technical skills to the students to study the microbiology and the students also will gain the knowledge in scientific understanding of microbiology working in this particular field in nineteenth and twentieth century. The knowledge in this field paves the path of microbial biotechnology.

Program Outcome: Gather botanical knowledge in microbiology with preliminary ideas.

Microbiology:

Biology & Diversity of Virus:

Nature and origin of virion: Nomenclature and classification (Baltimore, 1971) properties of viruses; Structure of viruses-capsid and their arrangements, Molecular organization of virion

with special reference to TMV and T4.

Viral replication: Lytic and Lysogenic cycles- Lytic cycle in T even phages, lysogeny in lambda phage. Sub viral particles- prions, viroids and virusoid.

Biology & Diversity of Bacteria:

Concept of pure culture in microbiology: Different methods of isolation of pure culture, Maintenance of Stock Culture, Systematic study of pure culture.

The morphology and fine structure of bacteria: The size, shape and arrangement of bacterial cell, Structure of bacterial cell: structure, type, orientation and function of flagella and mechanism of flagellar movement, Pili (Fimbriae), Capsule, Bacterial cytoplasmic membrane and membrane system; Bacterial cell wall- structure, difference between gram positive and gram negative bacterial cell wall. Bacterial endospore – structure, formation and significance; Plasmids – types, structure, properties and significance.

Cultivation of Bacteria: Bacteriological media – types and preparation: Nutritional types of bacteria: Autotrophs and Heterotrophs, Photolithotrophs and chemolithotrophs, photoorganotrophs and chemoorganotrophs, auxotrophs and prototrophs.

Bacterial Growth: Kinetics; growth curve; factors affecting growth; Growth in Batch culture and continuous culture; Synchronous growth; Measurement of growth; Diauxic growth and its significance.

Microbial Control: Important terminologies related to microbial control, preliminary ideas of sterilization by heat, chemical and UV.

Microbial metabolism and Energy production: Entner-Doudoroff pathway, Glyoxylate pathway, Bacterial photosynthesis in purple sulfur bacteria, purple non-sulfur bacteria and green non-sulfur bacteria – Elementary ideas only. Fermentation: alcoholic and lactic acid fermentation.

Bacterial Genetics: Organization and replication of bacterial chromosome and plasmid. Recombination in bacteria - conjugation, transformation and transduction. Lac operon.

Microbial ecology: Concept of microbial ecology with reference to air, water and soil.

Industrial microbiology: Industrial production of ethanol, penicillin and Cheese.

General account: Biological nitrogen fixation; Mycoplasmas and Actinomycetes. Economic importance of bacteria and viruses.

Course: Practical syllabus of Major 12

Paper Name: Microbiology

Paper Code: BOT MAJ 12L

Basic ideas about incubator, hot air oven, autoclave and laminar air flow. Preparation of solid and liquid media. Preparation of slant, stab and plate. Staining of micro flora from curd and root nodules. Gram staining. Preliminary idea of – serial dilution, streaking. Inoculation and sub culturing.

Suggested Readings:

1. General Microbiology by R.Y. Stanier, JL Ingrahm, ML Wheelis and PR Painter.
2. General Microbiology by HG Schlegel
3. Microbial Genetics by Maloy, J E Cronan and D Friefelder
4. Introduction to Modern Virology by NJ Dimmock, A J Easton and K N Leppard
5. Microbiology by Prescott L, Harley J, Klein D.
6. A Textbook of Microbiology: R C Dubey & D K Maheshwari

Course: Theory syllabus of Major 13

Paper Name: Research Methodologies and Ethics

Paper Code: BOT MAJ 13

Program Objective: The Major 13 offers essential knowledge and technical skills to the students to study the research methodologies and ethics and the students also will gain the knowledge in scientific understanding of research methodologies and ethics working in this particular field. The knowledge in this field paves the path doing their doctoral degree and research in other field of study.

Program Outcome: Gather botanical knowledge in research methodologies and ethics with preliminary ideas.

Theory:

1. Basic concepts of research: Research-definition and types of research (Descriptive vs analytical; applied vs fundamental; quantitative vs qualitative; conceptual vs empirical). Research methods vs methodology. Literature-review and its consolidation; Library research; field research; laboratory research.
2. General laboratory practices: Common calculations in botany laboratories. Understanding the details on the label of reagent bottles, molarity and normality of common acids and bases, Preparation of solutions. Dilutions. Percentage solutions. Molar, molal and normal solutions. Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures in their handling.
3. Data collection and documentation of observations: Maintaining a laboratory record; Tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars. The art of field photography.

4. Overview of Biological Problems: History; Key biology research areas, Model organisms in biology (A Brief overview): Genetics, Physiology, Biochemistry, Molecular Biology, Cell Biology.

5. Methods to study plant cell/tissue structure: Whole mounts, peel mounts, squash preparations, clearing, maceration and sectioning; Tissue preparation: living vs fixed, physical vs chemical fixation, coagulating fixatives, non-coagulant fixatives; tissue dehydration using graded solvent series; Paraffin and plastic infiltration; Preparation of thin and ultrathin sections.

6. Plant micro techniques: Staining procedures, classification and chemistry of stains. Staining equipment. Reactive dyes and flurochromes (including genetically engineered protein labeling with GFP and other tags). Cytogenetic techniques with squashed plant materials.

7. The art of scientific writing and its presentation: Numbers, units, abbreviations and nomenclature used in scientific writing. Writing references. PowerPoint presentation. Poster presentation, Scientific writing and ethics, Introduction to copyright-academic misconduct/plagiarism.

Philosophy of Ethics: Definition, Nature and scope, concept, moral philosophy, nature of moral judgments and reactions.

Scientific Conduct: Ethics with respect to science and research, Redundant Publications: duplicate and overlapping Publications, Salami Slicing, Scientific misconducts: falsification, fabrication and plagiarism, Intellectual honesty and Research integrity, Selective reporting and misrepresentation of data.

Publication Ethics: Publication ethics: definition, introduction and importance; Best practices/ standard settings initiatives and guidelines: COPE, WAME.

Bioethics in research: Introduction, ethical conflicts in biological sciences - interference with nature, cloning and genetically engineered food, environmental risk, labeling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – bio piracy.

Practical:

1. Demonstration of different methods of study plant cell/tissue structure and plant micro techniques – as per theory syllabus.
2. Methods to study plant cell/tissue structure – as per theory syllabus.
3. Preparation of Molar, molal and normal solutions.

Suggested Readings:

1. Research Methodology. Arvind Shende & Vijay Upagade; S Chand Publishing.
2. Research Methodology: Concept and Cases. Dr Deepak Chawla & Dr Neena Sondhi; Vikas Publishing.
3. Research Methodology and Research Ethics. Sagar Gaur, Dimpy Rathee and Saksham Dikshit, Book River.

Course: Theory syllabus of Major 14

Paper Name: Major 14

Paper Code: BOT MAJ 14

(Students will select any one topic from the following)

A) Bio-resource Management, Applied Botany and Evolution:

Program Objective: The 'Bio-resource Management, Applied Botany and Evolution' offers essential knowledge and technical skills to the students to study the bio-resource management, applied botany and evolution and the students also will gain the knowledge in scientific understanding of Plant biotechnologist working in this particular field in recent era. The knowledge in this field paves the path of biotechnology.

Program Outcome: Gather botanical knowledge in bio-resource management, applied botany and evolution with preliminary ideas.

Theory:

Bio-resource Management, Applied Botany and Evolution:

Introduction to Bio-resources and Biodiversity: Fundamental concepts of Bio-resources (plant, animal and microbial diversity), concept and levels of Biodiversity; Mega-biodiversity countries; Biodiversity hotspots (concept and distribution); Biodiversity and climate change— concerns and challenges; Valuing biodiversity— direct- and indirect use values; Role of remote sensing in Biodiversity studies. Biodiversity conservation. Biodiversity international, CIAT (International Centre for Tropical Agriculture), CGIAR, FAO.

Bio resources and Livelihood: Livelihood and its relation with bioresources management; Threats to traditional livelihood, food insecurity; Impact of globalization and urbanization on livelihood; Sustainable development; Energy crisis and need for green energy; Concept of green Building, vertical gardens; Green washing, eco-labelling (concept and examples).

Sustainable Bio-resource Management and Policies: Forest resource management, Crop resource management, Stubble (crop residue) management practices and its importance. Indian Bio resources, Information Network - organization and role; Convention on Biological Diversity (CBD)- Aims and objectives; Ramsar Convention; Environment Protection act 1986- Scope and objectives; Environment Impact Assessment (EIA)- Concept and stages of EIA; Biodiversity conservation and public participation. EMP (Environmental Management Plan), Biodiversity act 2022.

Applied Botany

Gardening, Landscaping and Garden Management: Fundamentals of landscape design, principles and styles of landscape design: flower beds, topiary, plant protection- pests, disease and weeds, miscellaneous growing techniques-bonsai, terrariums, hydroponics and aeroponics.

Horticulture: History of horticulture, fundamentals of horticulture, techniques of plant propagation, a brief account of pomology, olericulture, floriculture and ornamental horticulture, viticulture, applications of tissue culture in horticulture.

Botany in Forestry and Industry: Sustainable forestry management, forests as centers of biodiversity, social forestry and organic farming, silviculture. Brief description of biofuels and biodiesel, plants in cosmetic industry, aroma therapy and flower essence therapy, pharmaceutical industry, phytoremediation, plant indicators.

Evolution:

Evolutionary History of Origin of Life: Concept of Geological Time Scale, fundamental idea on Evolutionary Biology and its importance, Evolution and human health, Lamarck's and Darwin's concepts of Evolution, fundamental principles of biological evolution. Origin of cells and unicellular evolution, origin of basic biological molecules; concept of Oparin and Haldane; Miller's experiment (1953), origin of eukaryotic cells and evolution of unicellular eukaryotes (endosymbiotic hypothesis). Concept of radiometric dating.

The Hardy-Weinberg principle and Major Evolutionary Forces: The Hardy-Weinberg principle

and its significance. Detailed idea on Evolutionary forces – Mutation, Random Genetic Drift, Natural Selection, Inbreeding and Migration (gene flow).

The Origin of Species and Concept of Phylogeny: Concept of population, species and speciation, Microevolution and macroevolution, Biological Species Concept, reproductive isolation, pre- and post-zygotic barriers; limitations of Biological Species Concept. Phylogeny and evolutionary relationship, phylogenetic tree and its types (phylogram, cladogram and dendrogram), tools to construct phylogenetic trees, bootstrap and its significance.

Practical:

Preparation of nursery beds and seed germination studies.

Cutting, layering and grafting – demonstration.

Identification of common pest diseases and weeds.

Bonsai techniques.

Hydroponics using suitable plants.

Non timber forest products- collection and identification.

Field visit.

Suggested Readings:

1. An Advanced Textbook on Biodiversity: Principles and Practice, 2004, Krishnamurthy, Oxford and IBH Publishing ISBN, 8120416066, 9788120416062
2. Principles of conservation biology, Gary K. Meffe Conservation Biology for All, 2010, Navjot S. So-dhi and Paul R. Ehrlich, ISBN: 9780199554249
3. Essentials of Conservation Biology 6th Edition, Richard B. Primack, ISBN13: 978-1605352893, ISBN-10: 1605352896
4. Biodiversity: An Introduction, Kevin J. Gaston, John I. Spicer, Biodiversity, E.O. Wilson, National Academies Press, ISBN, 030956736X, ISBN: 9780309567367
5. Horticultural Practices and Post-Harvest Technology (2022) Mandal, Nag (Mandal) and Das. Books and Allied (P) Ltd., Kolkata.
6. Campbell Biology (10th Edition) Reece, Urry, Cain, Wasserman, Minorsky, Jackson. Pearson Publication.
7. Evolution (4th Edition) Futuyma, Kirkpatrick. Sinauer Associates, Inc. Publishers, 23 Plumtree Road, Sunderland, MA 01375 U.S.A.

B) Microbial Biotechnology

Program Objective: The Microbial Biotechnology offers essential knowledge and technical skills to the students to study the microbial biotechnology and the students also will gain the knowledge in scientific understanding of microbial biotechnology working in this particular field. The knowledge in this field paves the path doing their doctoral degree and research in other field of study.

Program Outcome: Gather botanical knowledge in microbial biotechnology with advance ideas.

Theory:

Basic Concept of Microbial Biotechnology: General introduction to microbial biotechnology, diversity of biotechnologically important microorganisms and rationale of utilization, basic concept of primary and secondary metabolism of microbes, primary and secondary metabolites for commercial interest, scope and applications.

Microbial Metabolism: Principles and concepts of microbial metabolism, ATP (the major energy currency of cells), redox reactions, electron transport chains, biochemical pathways linked to metabolism, role of enzymes and ribozymes, regulation of metabolism. Catabolism (fermentations and respirations) and anabolism (the use of energy in biosynthesis).

Microbial Products of Industrial Importance and Food Microbiology: Antibiotics, amino acids, organic acids, biopolymers, biosurfactants, biocatalysts, vaccines, biofuels, fermented products (foods, alcoholic beverages), probiotics. Food borne diseases, spoilage of food, methods of food preservation.

Synthetic Biology, BioBricks and Genetic Engineering: Concept of synthetic biology, a brief introduction to BioBricks in microbial product development. Tools of genetic engineering for manipulation of DNA (PCR, polymerases, PCR applications and RT-PCR, gel electrophoresis and nucleic acid hybridization). Concept of molecular cloning and restriction enzymes, recombineering (recombination-mediated genetic engineering), cloning vectors and hosts for cloning vectors.

Transgenic Organisms in Agriculture and Aquaculture: The Ti plasmid and transgenic plant, herbicide- and insect-resistant plants, transgenic fish.

Engineered Vaccines and Therapeutic Agents: Problems with traditional vaccines, impact of biotechnology on vaccine development, recombinant vaccines, mechanisms for producing immunity, Vaccinia virus, and Subunit vaccines. Commensal bacteria and therapeutic delivery, pathogens as engineered anticancer therapies.

Synthetic Food Products and Pharmaceuticals: Engineering Vanillin using *E. coli* and yeast, synthetic pharmaceuticals: Artemisinin and Malaria.

Practical:

Enumeration of soil microorganisms by serial dilution agar plate method.

Study of bacterial isolates with respects to production of following enzymes – amylase, catalase, lipase and protease.

Study of bacterial isolates with respect to fermentation of carbohydrates.

Enumeration of coliforms from foods/ water by MPN methods.

Detection of antibiotic /heavy metal resistance enterobacteriaceae member from water sample.

Isolation nitrogen fixing bacteria from soil.

Laboratory visit.

Suggested Readings:

1. Brock Biology of Microorganisms (16th Global Edition), Madigan, Bender, Buckley, Sattley, Stahl. Pearson publication.
2. Prescott's Microbiology (11th Edition), Willey, Sandman, Wood. McGraw Hill Education.
3. Microbial Biotechnology, Fundamentals of Applied Microbiology (2nd Edition), A.N. Glazer, H. Nikaido. Cambridge University Press.

Course: Theory syllabus of Major 15

Paper Name: Major 15

Paper Code: BOT MAJ 15

Plant biotechnology & Tissue culture:

Program Objective: This course offers essential knowledge and technical skills to the students to study the Plant biotechnology & Tissue culture and the students also will gain the knowledge in scientific understanding of Plant biotechnologist working in this particular field in recent era. The knowledge in this field paves the path of biotechnology.

Program Outcome: Gather botanical knowledge in Plant biotechnology & Tissue culture with preliminary ideas.

Theory:

A. Plant Biotechnology:

Recombinant DNA technology: Restriction Endonucleases (History, Types, biological role and application); Restriction Mapping (Linear and Circular); Cloning Vectors: Prokaryotic (pUC 18 and pUC19, pBR322, Ti plasmid, BAC); Lambda phage, M13 phagemid, Cosmid, Shuttle vector; Eukaryotic Vectors (YAC).

Gene Cloning: Recombinant DNA, Bacterial Transformation and selection of recombinant clones, PCR mediated gene cloning; Gene Construct; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; complementation, colony hybridization; PCR

Methods of gene transfer: *Agrobacterium* –mediated gene transfer, Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment; Selection of transgenics– selectable marker and reporter genes (Luciferase, GUS, GFP)

Applications of Biotechnology: Pest resistant (Bt-cotton); herbicide resistant plants (Roundup Ready soybean); Transgenic crops with improved quality traits (FlavrSavr tomato, Golden rice); Improved horticultural varieties (Moon dust carnations); Role of transgenic in bioremediation (Superbug); edible vaccines; Industrial enzymes (Aspergillase, Protease, Lipase); Biosafety: Definition, objectives and guidelines in India and abroad, risk assessment (during laboratory research, for planned introduction, biotechnology products), risk regulations, planned introduction of GM plants.

B. Plant Tissue Culture:

Laboratory Organization and Techniques in plant tissue culture: General idea about plant tissue culture medium, techniques, glass goods and media.

Cytodifferentiation: Introduction, definition, principle, protocol, general account and different factors involved in cytodifferentiation.

Organogenesis: Introduction, definition, principle, protocol, applications and different factors involved in organogenesis.

Totipotency: Introduction, definition, expression, and significance of totipotency in plant science.

Callus Culture: Introduction, definition, principle, protocol, and significance of callus culture. Formation, morphology, anatomy and other characteristics of callus tissue. Somaclonal variation

Cell suspension culture: Introduction, definition, principle, protocol, general account, different categories growth pattern and significance of cell suspension culture.

Somatic Embryogenesis and Artificial Seeds: Introduction, definition, principle, protocol, im-

portance and applications of somatic embryogenesis and artificial seed production. Embryonic Potential and Embryoids – brief idea only.

Single Cell Culture: Introduction, definition, principle, protocol, importance and different factors involved in single cell culture.

Protoplast Fusion and Somatic Hybridization: Introduction, methods of protoplast fusion – spontaneous fusion, induced fusion, mechanical fusion, chemo-fusion; electrofusion; mechanism of protoplast fusion; hybrid identification; hybrid isolation, post fusion events, cybrids; importance.

Application and importance of plant tissue culture: Micropropagation; Clonal propagation; Production of genetically variable plants; Application in plant pathology, plant breeding, plant improvement, production of useful biomedical, biotechnology, forestry and Gene conservation bank.

Practical: Seminar Presentation.

Suggested Readings:

1. Genetics, B.D Singh; Kalyani Publishers; Ludhiana.
2. Plant Tissue Culture. Kalyan Kumar De. New Central Book Agency.
3. Advanced Biotechnology. R C Dubey. S Chand Publishing

For Botany (Major) Hon with Research

Course: Theory syllabus of Major 16

Paper Name: Dissertation

Paper Code: BOT MAJ 16

Program Objective: These courses offer essential knowledge and technical skills to the students to conduct research and the students also will gain the knowledge in scientific understanding of research program working in this particular field in recent era. The knowledge in this field paves the path obtaining research degree.

Program Outcome: Gather preliminary knowledge and experience to do research in their field of interest.

For **Major 16** under 4 Year Degree program under NCCF 2023 are as follows: Dissertation: 75 marks (Written 50 and Presentation and viva voce 25); Internal assessment 25 (Attendance 05; Continuous evaluation: 20).

For Botany (Major) Hon

Course: Theory syllabus of Major 16

Paper Name: Pharmacognosy

Paper Code: BOT MAJ 16

Program Objectives: To develop a comprehensive understanding of the medicinal properties and therapeutic applications of plants, along with the principles and techniques of pharmacognosy involved in the development and evaluation of plant-based medicines.

Program outcome: This course aims to develop a thorough understanding of the pharmacological properties of plant-derived compounds, including their mechanisms of action and therapeutic

tic potential. It also enables students to acquire practical knowledge and skills related to the identification, collection, processing, quality assessment, extraction, and isolation of medicinal plants and their bioactive constituents. Further, the course equips students to apply principles of pharmacognosy and pharmacological evaluation to assess the safety, efficacy, and quality of plant-based medicines, while fostering the ability to critically analyze scientific literature in the fields of plant pharmacology and pharmacognosy.

Theory:

Introduction to Plant Pharmacognosy: Overview of plant pharmacology and pharmacognosy, History of Pharmacology and pharmacognosy, Principles of pharmacology and drug discovery, Role of medicinal plants in healthcare practices. Alternative systems of medicine: Ayurveda, Siddha, Unani, Homeopathy (overview); Ethical considerations and sustainability in plant-based medicine.

Analytical Pharmacognosy & Quality Evaluation and Characterization: Phytochemistry: Extraction techniques for plant bioactive compounds, Chromatographic separation methods, Spectroscopic techniques for compound identification, Drug adulteration: Types and methods of detection. Plants used for the treatment of hepatic disorders, cardiac diseases, infertility, diabetes, blood pressure, cancer and skin diseases.

Pharmacological Activities and Mechanisms of Action: Phytochemical screening tests for secondary metabolites (alkaloids, glycosides, steroids, triterpenoids, flavonoids, tannins and other phenolic compounds). Bioassays for evaluating pharmacological activities, Pharmacodynamics and pharmacokinetics of plant compounds.

Applied Pharmacognosy and Regulatory Perspectives: Propagation of important species (*Withania somnifera*, *Rauvolfia serpentina*, *Andrographis paniculata*, *Cymbopogon citratus* and *Ocimum sanctum*). Herbal foods- future of Pharmacognosy; Plant toxins and natural poisons, Safety, efficacy and regulatory, quality control aspects of herbal drugs. Role of biotechnology in drug development. Role of AYUSH, NMPB in the promotion of medicinal plants. Cultiva;

Practical:

Organoleptic study of *Zinziber officinale*, *Curcuma longa*, *Alstonia scholaris* and *Adhatoda vasaka*.

Test for fats and oil: Saponification test.

Test for tannin; alkaloids, phenol, glycosides gum and resins,

Morphological identification of medicinally important plant parts

Suggested Readings:

1. Natural Products from plants, 1st edn, by Peter B. Kaufman, CRC press, Newyork, 1998 5.
2. Glimpses of Indian Ethanopharmacology by P. Pushpangadam,UIF Nyman, V.George, Tropical botanic Garden and research institute., 1995
3. Textbook of Pharmacognosy and Phytochemistry 2nd Edition by Seth, S. D. & Shah, B. CBS Publishers & Distributors Pvt. Ltd., New Delhi. 2016.
4. Text book of Pharmacognosy, by G.E.Treese nad W.C.Evans, 15th edn, W.B. Saunders Edenburg, NewYork.,
5. Text book of Pharmacognosy by C.K.Kokate, Purohit, Ghokhale, 5th edn nirali prakassan., 1996

Course: Theory syllabus of Major 17

Paper Name: Laboratory Techniques and Instrumentations

Paper Code: BOT MAJ 17

Program Objective: The Major 17 offers essential knowledge and technical skills to the students to study the laboratory techniques and instrumentations and the students also will gain the knowledge in scientific understanding of various laboratory techniques and instrumentations used by plant biotechnologist working in recent era. The knowledge in this field paves the path of biotechnology. This course also familiarizes the students with theoretical aspects of imaging, biochemical and molecular techniques that are used extensively in plant sciences as well as attempts to familiarize the students with the working principle of major instruments used in biological research.

Program Outcome: Gather botanical knowledge in laboratory techniques and instrumentations with preliminary ideas. They will learn about the advanced instrumentation techniques, basic working principle of major instruments and understand the concepts, techniques and applications of various instruments

Theory:

Imaging Techniques and microscopy: Principles and applications of light microscopy, fluorescence microscopy, phase contrast microscopy, confocal microscopy and Transmission electron microscopy and scanning electron microscopy.

Principles, column, matrix and application of chromatography: Column chromatography, Paper Chromatography, Thin Layer Chromatography (TLC), Ion-exchange Chromatography, Affinity Chromatography and High Performance Liquid Chromatography (HPLC).

Centrifugation Technique: Introduction, basic principle of sedimentation, different centrifuges and their uses, Density gradient centrifugation - Basic idea.

Electrophoretic Techniques: Principle, support media, Sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS PAGE) of Protein, Isoelectric focusing (IEF) gel, Two dimensional polyacrylamide gel electrophoresis (2-D PAGE), Detection, estimation and recovery of proteins. Agarose gel electrophoresis of DNA, DNA sequencing gel, Pulsed field gel electrophoresis (PFGE), Electrophoresis of RNA.

Spectroscopic Techniques: Introduction, Principles and application of Colorimetry and Spectrophotometry (UV and visible light spectroscopy) Principle, instrumentation and application of Nuclear magnetic resonance spectroscopy (NMR).

Immunochemical techniques: General principle of Antigen and Antibody Interaction. Antibody Production and Immuno-diffusion. Principle, practical aspects of Radioimmunoassay (RIA). Enzyme Linked Immuno-Sorbent Assay (ELISA). Fluorescent Immunoassay (FIA).

Molecular Biology technique: Basic principles and applications of molecular techniques, Nucleic acid hybridization: in situ hybridization, southern hybridization, northern hybridization and western blotting. Colony hybridization. Molecular marker- RAPD, AFLP, RFLP, PCR (basic variant). Fluorescence in situ hybridization (FISH), clustered regularly interspaced short palindromic repeats (CRISPR) and DNA sequencing,

Protein and Enzyme techniques: Total protein estimation, Protein purification, Enzyme assay techniques – general considerations (visible and ultraviolet spectrophotometric method only).

Radioisotope techniques: Nature of radioactivity, detection and measurement of radioactivity, radioactivity and half-life, radioisotopes, units of radioactivity, advantages and restriction of radioisotope experiments, safety aspects, applications of radioisotopes in Biology.

Practical:

Estimation of total carbohydrates from plant samples.

Estimation of proteins from plant samples by Folin-Lowry/Biuret method.

Extraction and quantification of chlorophylls and carotenoids from plant samples.

Extraction and separation of plant pigments following Thin Layer Chromatography (TLC).

Separation of amino acids by Paper Chromatography.

Suggested Readings:

1. Principles of Laboratory Techniques and Methods. M Srivastava. CBS Publishers & Distributors.
2. Practical biochemistry, Principles and techniques. Keith Wilson and John Walker (Eds). Cambridge Low Price Edition.

Course: Theory syllabus of Major 18

Paper Name: Major 18

Paper Code: BOT MAJ 18

(Students of **Botany Major with Hon with Research** will select any one topic from the following **baskets of elective subjects for Major 18 A**. Pharmacognosy, B. Microbial Biotechnology, C. Plant breeding, biostatistics and bioinformatics. (Students will select any one topic from the basket).

(Students of **Botany Major with Hon only** will select any one topic from the following **baskets of elective subjects for Major 18 B**. Microbial Biotechnology, C. Plant breeding, biostatistics and bioinformatics.).

A) Pharmacognosy:

Program Objectives: To develop a comprehensive understanding of the medicinal properties and therapeutic applications of plants, along with the principles and techniques of pharmacognosy involved in the development and evaluation of plant-based medicines.

Program outcome: This course aims to develop a thorough understanding of the pharmacological properties of plant-derived compounds, including their mechanisms of action and therapeutic potential. It also enables students to acquire practical knowledge and skills related to the identification, collection, processing, quality assessment, extraction, and isolation of medicinal plants and their bioactive constituents. Further, the course equips students to apply principles of pharmacognosy and pharmacological evaluation to assess the safety, efficacy, and quality of plant-based medicines, while fostering the ability to critically analyze scientific literature in the fields of plant pharmacology and pharmacognosy.

Theory:

Introduction to Plant Pharmacognosy: Overview of plant pharmacology and pharmacognosy, History of Pharmacology and pharmacognosy, Principles of pharmacology and drug discovery, Role of medicinal plants in healthcare practices. Alternative systems of medicine: Ayurveda, Siddha, Unani, Homeopathy (overview); Ethical considerations and sustainability in plant-based medicine.

Analytical Pharmacognosy & Quality Evaluation and Characterization: Phytochemistry: Extrac-

tion techniques for plant bioactive compounds, Chromatographic separation methods, Spectroscopic techniques for compound identification, Drug adulteration: Types and methods of detection. Plants used for the treatment of hepatic disorders, cardiac diseases, infertility, diabetes, blood pressure, cancer and skin diseases.

Pharmacological Activities and Mechanisms of Action: Phytochemical screening tests for secondary metabolites (alkaloids, glycosides, steroids, triterpenoids, flavonoids, tannins and other phenolic compounds). Bioassays for evaluating pharmacological activities, Pharmacodynamics and pharmacokinetics of plant compounds.

Applied Pharmacognosy and Regulatory Perspectives: Propagation of important species (*Withania somnifera*, *Rauvolfia serpentina*, *Andrographis paniculata*, *Cymbopogon citratus* and *Ocimum sanctum*). Herbal foods- future of Pharmacognosy; Plant toxins and natural poisons, Safety, efficacy and regulatory, quality control aspects of herbal drugs. Role of biotechnology in drug development. Role of AYUSH, NMPB in the promotion of medicinal plants. Cultiva;

Practical:

Organoleptic study of *Zinziber officinale*, *Curcuma longa*, *Alstonia scholaris* and *Adhatoda vasaka*.

Test for fats and oil: Saponification test.

Test for tannin; alkaloids, phenol, glycosides gum and resins,

Morphological identification of medicinally important plant parts

Suggested Readings:

1. Natural Products from plants, 1st edn, by Peter B. Kaufman, CRC press, Newyork, 1998 5.
2. Glimpses of Indian Ethanopharmacology by P. Pushpangadam, UIF Nyman, V.George, Tropical botanic Garden and research institute., 1995
3. Textbook of Pharmacognosy and Phytochemistry 2nd Edition by Seth, S. D. & Shah, B. CBS Publishers & Distributors Pvt. Ltd., New Delhi. 2016.
4. Text book of Pharmacognosy, by G.E.Treese and W.C.Evans, 15th edn, W.B. Saunders Edenburg, NewYork.,
5. Text book of Pharmacognosy by C.K.Kokate, Purohit, Ghokhale, 5th edn nirali prakassan., 1996

B) Microbial Biotechnology

Program Objective: The Microbial Biotechnology offers essential knowledge and technical skills to the students to study the microbial biotechnology and the students also will gain the knowledge in scientific understanding of microbial biotechnology working in this particular field. The knowledge in this field paves the path doing their doctoral degree and research in other field of study.

Program Outcome: Gather botanical knowledge in microbial biotechnology with advance ideas.

Theory:

Basic Concept of Microbial Biotechnology: General introduction to microbial biotechnology, diversity of biotechnologically important microorganisms and rationale of utilization, basic concept of primary and secondary metabolism of microbes, primary and secondary metabolites for commercial interest, scope and applications.

Microbial Metabolism: Principles and concepts of microbial metabolism, ATP (the major energy currency of cells), redox reactions, electron transport chains, biochemical pathways linked to metabolism, role of enzymes and ribozymes, regulation of metabolism. Catabolism (fermentations and respirations) and anabolism (the use of energy in biosynthesis).

Microbial Products of Industrial Importance and Food Microbiology: Antibiotics, amino acids, organic acids, biopolymers, biosurfactants, biocatalysts, vaccines, biofuels, fermented products (foods, alcoholic beverages), probiotics. Food borne diseases, spoilage of food, methods of food preservation.

Synthetic Biology, BioBricks and Genetic Engineering: Concept of synthetic biology, a brief introduction to BioBricks in microbial product development. Tools of genetic engineering for manipulation of DNA (PCR, polymerases, PCR applications and RT-PCR, gel electrophoresis and nucleic acid hybridization). Concept of molecular cloning and restriction enzymes, recombineering (recombination-mediated genetic engineering), cloning vectors and hosts for cloning vectors.

Transgenic Organisms in Agriculture and Aquaculture: The Ti plasmid and transgenic plant, herbicide- and insect-resistant plants, transgenic fish.

Engineered Vaccines and Therapeutic Agents: Problems with traditional vaccines, impact of biotechnology on vaccine development, recombinant vaccines, mechanisms for producing immunity, Vaccinia virus, and Subunit vaccines. Commensal bacteria and therapeutic delivery, pathogens as engineered anticancer therapies.

Synthetic Food Products and Pharmaceuticals: Engineering Vanillin using *E. coli* and yeast, synthetic pharmaceuticals: Artemisinin and Malaria.

Practical:

1. Enumeration of soil microorganisms by serial dilution agar plate method.
2. Study of bacterial isolates with respects to production of following enzymes – amylase, catalase, lipase and protease.
3. Study of bacterial isolates with respect to fermentation of carbohydrates.
4. Enumeration of coliforms from foods/ water by MPN methods.
5. Detection of antibiotic /heavy metal resistance enterobacteriaceae member from water sample.
6. Isolation nitrogen fixing bacteria from soil.
7. Laboratory visit.

Suggested Readings:

1. Brock Biology of Microorganisms (16th Global Edition), Madigan, Bender, Buckley, Sattley, Stahl. Pearson publication.
2. Prescott's Microbiology (11th Edition), Willey, Sandman, Wood. McGraw Hill Education.
3. Microbial Biotechnology, Fundamentals of Applied Microbiology (2nd Edition), A.N. Glazer, H. Nishikado. Cambridge University Press.

C) Plant breeding, Biostatistics and Bioinformatics:

Program Objective: The course offers essential knowledge and technical skills to the students to study the plant breeding, biostatistics and bioinformatics and the students also will gain the knowledge in scientific understanding of Plant biotechnologist working in this particular field in recent era. The knowledge in this field paves the path of biotechnology.

Program Outcome: Gather botanical knowledge in plant breeding, biostatistics and bioinformatics with preliminary ideas.

Theory:

A. Plant Breeding:

Plant breeding: An overview, objectives, achievements, and prospects.

Methods in plant breeding: Breeding for self and cross pollinated crops:

Breeding for self-pollinated crops: Principles: Selection in self-pollinated crops; Hybridization – techniques and Consequences; heterosis and hybrid vigour; inbreeding depression.

Methods: Mass selection; Pureline selection; Pedigree selection, Bulk method; Backcross method; Effectiveness of different breeding methods for Self-pollinated crops.

Breeding for cross-pollinated crops: Population improvement: Introduction, methods of population improvement and objectives of selection; Mass selection; Progeny selection; applications and achievements of mass selection and progeny selection; recurrent selection; hybrid and synthetic varieties: Introduction; definition; developments and evaluation of inbreeds; production of hybrid seeds; improving the characteristics of inbreed lines; merits and demerits of hybrid varieties.

Synthetic varieties: Definition, production, maintenance of synthetic varieties; merits and demerits of synthetic varieties.

Breeding for clonal crops: Clonal selection and hybridization: Introduction; Characteristics of asexually propagated crops; Clones and origin of genetic variations within the clones; comparison among clones, purelines and inbreeds; clonal degeneration; methods of improvements; clonal selection; hybridization (including interspecific hybridization); achievements.

Polyploidy in plant breeding and Evolution of major crops: Introduction; application of aneuploidy and autopolyploidy in crop improvement; role of allopolyploidy in evolution; evolution of *Triticum aestivum* and *Nicotiana tabacum*; application of allopolyploidy in crop improvement; limitation of autopolyploidy and allopolyploidy.

B. Biostatistics:

Importance and application of Biostatistics in biological sciences.

Sampling and sample designs: Classification and tabulation of data; Visualizing data (diagrammatic and graphical presentation), Detail account of random sampling, frequency distribution, measurement of central tendency– arithmetic mean, mode and median, measurement of dispersion – standard deviation, standard error of mean.

Test of significance: 't'- test; chi- square test for goodness of fit. ANOVA;

Regression and correlation: Basic concept.

Probability distributions: Concept of Probability, Binomial Distribution and Poisson Distribution

C. Bioinformatics:

Introduction to the concept of hardware and software. Introduction to Windows, UNIX and Linux; Introduction to Perl and Python.

Different types of biological databases: Sequence databases, structural, genomic and pathway interaction databases; information retrieval from biological databases; sequence analysis overview. Introduction to genome browsers; Online bioinformatics tools. Different types of file formats used in bioinformatics analysis; Genome annotation.

Sequence analysis: Nucleotide and protein sequence analysis, sequence alignment and applications. Multiple sequence alignments and Phylogenetic alignments, codon usages; phylogenetic analysis. single nucleotide polymorphism (SNP),

Introduction to protein structure prediction and analysis; drug designing.

Brief idea: Pubmed, NCBI, DDBJ, IMG-JGI, Swissprot, EMBL, Genbank and Entrez.

Practical:

Practical Plant Breeding:

Demonstration of emasculation, bagging and tagging.

Practical Bioinformatics:

Introduction and use of various genome databases using NCBI.

Sequence information resource: Using NCBI, EMBL, Genbank and Swissprot.

Similarity searches using tools like BLAST and interpretation of results.

Multiple sequence alignment using ClustalW.

Phylogenetic analysis of protein and nucleotide sequences.

Use of different protein structure prediction databases (PDB, SCOP, CATH).

Practical Biostatistics:

Univariate analysis of statistical data: Statistical tables, mean, mode, median, standard deviation and standard error (leaflet size).

Determination of goodness of fit in normal and modified mono-and dihybrid ratios (3:1, 1:1, 9:7, 13:3, 15:1, 9:3:3:1, 1:1:1:1) by Chi-square analysis and comment on the nature of inheritance.

Reference:

1. Plant Breeding, B.D Singh; Kalyani Publishers; Ludhiiana.
2. Cytogenetics, Evolution, Biostatics and Plant Breeding; P S Chandel & R S Shukla. S Chand Publishing
3. Bioinformatics: Genomics and Proteomics. Dr. Ruchi Singh. Vikas Publishing.
4. Advanced Biotechnology. R C Dubey. S Chand Publishing

Course: Theory syllabus of Major 16 and Major 19

Paper Name: Dissertation

For Botany (Major) Hon with Research

Course: Theory syllabus of Major 19

Paper Name: Dissertation

Paper Code: BOT MAJ 19

Program Objective: These courses offer essential knowledge and technical skills to the students to conduct research and the students also will gain the knowledge in scientific understanding of research program working in this particular field in recent era. The knowledge in this field paves the path obtaining research degree.

Program Outcome: Gather preliminary knowledge and experience to do research in their field of interest.

For **Major 16** under 4 Year Degree program under NCCF 2023 are as follows: Dissertation: 75 marks (Written 50 and Presentation and viva voce 25); Internal assessment 25 (Attendance 05; Continuous evaluation: 20).

For Botany (Major) Hon

Course: Theory syllabus of Major 19

Paper Name: Molecular Biology

Paper Code: BOT MAJ 19

Molecular Biology:

Program objectives: To acquire a comprehensive understanding of genetic material, the central dogma of molecular biology, the genetic code, DNA replication, transcription, post-transcriptional modification, translation, and the regulation of gene expression.

Program Outcomes: By the end of this course, students will understand the structure and function of DNA and RNA, the role of nucleic acids as carriers of genetic information, the genetic code, DNA replication, the regulation of transcription and translation, and the mechanisms controlling gene expression in both prokaryotes and eukaryotes.

Theory

Nucleic acids: Carriers of genetic information: Historical perspective; DNA as the carrier of genetic information (Griffith's, Hershey & Chase, Avery, McLeod & McCarty, Fraenkel-Conrat's experiment)

The Structures of DNA and RNA / Genetic Material: DNA Structure: Miescher to Watson and Crick-historic perspective, DNA structure, salient features of double helix, types of DNA, types of genetic material, denaturation and renaturation (only melting profile- T_m), cot curves; RNA Structure, types of RNA (mRNA, rRNA, tRNA, small RNAs). Organelle DNA - mitochondria and chloroplast DNA. Euchromatin, Heterochromatin- Constitutive and Facultative heterochromatin, Split genes (Phillip Sharp).

The replication of DNA: Chemistry of DNA synthesis (Kornberg's discovery); General principles

– bidirectional, semiconservative and semi discontinuous replication, RNA priming; DNA replication; rolling circle and θ (theta) mode of replication, replication of linear ds-DNA, replication of the 5' end of linear chromosome; Enzymes involved in DNA replication.

Central dogma and genetic code : The Central Dogma (Adaptor hypothesis and discovery of mRNA template), Genetic code (deciphering & salient features). Adaptor hypothesis by Crick; Baltimore and Temin's discovery of reverse transcription.

Transcription: Transcription in prokaryotes. Principles of transcriptional regulation; Eukaryotes: transcription factors, heat shock proteins, steroids and peptide hormones. Regulation of lactose and tryptophan metabolism in *E. coli*, transcription factors, Co-transcriptional regulation. Transcription in prokaryotes and eukaryotes. Split genes-concept of introns and exons, removal of introns,

Processing and modification of RNA: Split genes-concept of introns and exons, processing of pre-RNA molecules, Catalytic activity of RNA molecules: spliceosome machinery, splicing pathways, group I and group II intron splicing, alternative splicing eukaryotic mRNA processing (5' cap, 3' poly A tail); Ribozymes; RNA editing and mRNA transport.

Translation in prokaryotes: Charging of tRNA, aminoacyl tRNA synthetases; Various steps in protein synthesis, proteins involved in initiation, elongation and termination of polypeptides; Fidelity of translation; Inhibitors of protein synthesis; Basic concept of Post-translational modifications of proteins.

Genome Editing, CRISPR/Cas9 system and Biocontainment of GMOs: Brief idea on genome editing, Clustered Regularly Interspaced Short Palindromic Repeat (CRISPR)/ Cas9 (Cas9 refers to CRISPR associated protein 9) systems. Environmental concerns regarding genetically modified organisms (GMOs) and its management.

The World of "Omics": Concept and applications of Genomics, Transcriptomics, Proteomics, Metabolomics and Metagenomics.

Practical

Isolation of genomic DNA Isolation of genomic DNA from *E.Coli*/ any plant samples using CTAB method and quantification using agarose gel electrophoresis.

DNA estimation by diphenylamine reagent/UV Spectrophotometry.

Study of DNA replication mechanisms through photographs (Rolling circle, Theta replication and semi-discontinuous replication).

Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs.

Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)

Study of the following through photographs: Assembly of Spliceosome machinery; Splicing mechanism in group I & group II introns; Ribozyme and Alternative splicing.

Suggested Readings:

1. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology of the Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons Inc., U.S.A. 5th edition.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings. U.S.A. 9th edition.

4. Russell, P. J. (2010). i-Genetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3rd edition.
5. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.
6. Ghosh A.K., Bhattacharya K., Hait G., (2015). A Text Book of Botany. Volume 3. New Central Book Agency (P) Ltd., Kolkata.