UNIVERSITY OF CALCUTTA

Notification No. CSR/43/2026

It is notified for information of all concerned that in terms of the provisions of Section 54 of the Calcutta University Act, 1979, (as amended), and, in the exercise of his powers under 9(6) of the said Act, the Vice-Chancellor has, by an order dated 21.04.2026, approved the revised complete Syllabus including Examination Modalities & Course Outcomes of 4-year Honours & Honours with Research and 3-year MDC of Botany under CCF,2022.

The above shall take effect from the Even semester examinations, 2026 and onwards.

08/05/2026

Prof.(Dr.) Debasis Das

Registrar

SENATE HOUSE

Kolkata-700073

08.05.2026

Course Structure- 4 yr
Honours and Honours with Research
(NEP 2020) BOTANY
UNIVERSITY OF CALCUTTA

UNIVERSITY OF CALCUTTA

Course Structure- 4 yr Honours + Research (NEP 2020) BOTANY

Programme Structure for the Bachelor of Science Degree with BOTANY as Major having Practicals									
Sem	**DSC/Core**	**Minor**	**IDC**	**AEC**	**SEC**	**CVAC**	**Summer Internship/ Field Visit**	**Dissertation/Research work**	**Total Credit**
	Level 100								
1	**BOT-H-CC1-1-Th BOT-H-CC1-1-P Plant diversity**	**Plant diversity (Th+Pr)**	**Plants Around Us****	**From Central Pool**	**BOT-H-SEC-1-Th BOT-H-SEC-1-P Mushroom Cultivation Technology**	**1. ENVS 2. CV**			**21**
2	**BOT-H-CC2-2-Th BOT-H-CC2-2-P Plant Systematics**	**Plant Systematics (Th+Pr)**		**From Central Pool**	**BOT-H-SEC-2-Th BOT-H-SEC-2-P Biofertilizer & Biopesticides**	**1. ENVS 2. Central Pool**	**Summer Internship *****		**21**
	Level 200						**Exit option**		
3	**BOT-H-CC3-3-Th BOT-H-CC3-3-P Economic Botany**	**Plant diversity (Th+Pr)**		**From Central Pool**	**BOT-H-SEC-3-Th BOT-H-SEC-3-P Plant Tissue Culture and Horticultural Practices**				**21**
	BOT-H-CC4-3-Th BOT-H-CC4-3-P Plant Anatomy and Embryology								
4	**BOT-H-CC5-4-Th BOT-H-CC5-4-P Phycology**	**Plant Systematics (Th+Pr)**		**From Central Pool**					**22**
	BOT-H-CC6-4-Th BOT-H-CC6-4-P Archegoniates								
	BOT-H-CC7-4-Th BOT-H-CC7-4-P Palaeobotany								
	BOT-H-CC8-4-Th BOT-H-CC8-4-P Pharmacognosy and Ethnobotany						**Summer Internship *****		
	Level 300						**Exit option**		
5	**BOT-H-CC9-5-Th BOT-H-CC9-5-P Mycology**	**M1: Economic Botany (Th+Pr) M2: Pharmacognosy and Ethnobotany (Th+Pr)**							**24**
	BOT-H-CC10-5-Th BOT-H-CC10-5-P Microbiology								
	BOT-H-CC11-5-Th BOT-H-CC11-5-P Biochemistry								
	BOT-H-CC12-5-Th BOT-H-CC12-5-P Cell and Molecular Biology								
6	**BOT-H-CC13-6-Th BOT-H-CC13-6-P Phytopathology**	**M1: Economic Botany (Th+Pr) M2: Pharmacognosy and Ethnobotany (Th+Pr)**							**23**

	BOT-H-CC14-6-Th BOT-H-CC14-6-P Plant Physiology								
	BOT-H-CC15-6-Th BOT-H-CC15-6-P Genetics						Summer Internship ***		
	Level 400						Exit option		
7	BOT-H-CC16-7-Th BOT-H-CC16-7-P Plant Geography, Ecology and Evolution								20
	BOT-H-CC17-7-Th BOT-H-CC17-7-P Biostatistics								
	BOT-H-CC18-7-Th BOT-H-CC18-7-P Plant Biotechnology								
	BOT-H-CC19-7-Th BOT-H-CC19-7-P Plant Metabolism								
	BOT-H-CC20-7-Th BOT-H-CC20-7-P Natural Resource Management (Th+Pr)								
8	BOT-H-CC21-8-Th BOT-H-CC21-8-P Research Methodology-1								20
	BOT-H-CC22-8-Th BOT-H-CC22-8-P Research Methodology-2								
Credits	88	32	9	8	12	8	3	12	172
Marks	2200#	800#	225##	200	300#	200	75	300	4300

***Candidates who will not pursue Dissertation/ Research work, he/she will have to study 1 additional DSC/Core paper of 4 credits in the 7th Semester & 2 DSC/Core papers of 4 Credits each in the 8th Semester.**

**** IDC offered from Botany to be opted in 1st or 2nd or 3rd semester.**

***** Summer internship once in 2nd or 4th or 6th Semester according to the exit option.**

#For 100 marks paper 75 marks for theory and 25 marks for practical. ## For 75 marks paper 50 marks for theory and 25 marks for practical.

Minor courses will come from two subjects of same broad discipline as Major (m1&m2). Students shall study two papers from a single Minor subject (both either from m1 or m2) in semester-V and shall study two papers from another Minor subject (both either from m1 or m2) in semester VI. The Minor subject to be studied in semester-6 shall be different from the Minor subject studied in semester-5.

In semester-7: Both Honours Programme and Honours with Research programme will study 5 (FIVE) core papers.

In semester-8: Research Methodology (RM-1 & RM-2) to be studied in both Honours Programme and Honours with Research programme.

Honours with Research Programme: Research Internship: BOT-H-CC26-8-Th; BOT-H-CC26-8-P (4 credits; 3Th + 1 viva) and Dissertation/Project-BOT-H-CC27-8-Th; BOT-H-CC27-8-P (8 credits; 6Th+2Viva)

Honours Programme : 5 core papers. That include RM1& RM along with Plant Breeding: BOT-H-CC23-8-Th, BOT-H-CC23-8-P ; Stress Biology: BOT-H-CC24-8-Th, BOT-H-CC24-8-P; Industrial Microbiology: BOT-H-CC25-8-Th; BOT-H-CC25-8-P.

Semester 1

DSC/Core
PLANT DIVERSITY (THEORY)
BOT-H-CC1-1-Th
Total marks 75; Credits 3, Class 45 hours

1. Introduction to plant kingdom.

1.1 Origin of life and evolution of plant cells, 1.2 Importance of plants as source of food, fuel and their role in ecosystem services (as carbon sink, sequestering)

(3 lectures)

2. Algae

2.1. Algae a general account. Salient features of Cyanophyceae, Chlorophyceae, Charophyceae, Phaeophyceae, Rhodophyceae and Bacillariophyceae 2.2. Economic importance of algae in environment, agriculture, biotechnology and industry.

(6 lectures)

3. Fungi

3.1 Salient features of Myxomycota, Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina, Deuteromycotina. 3.2 System of classification up to Sub-division (Ainsworth, 1973), 3.3 Economic importance of fungi (food, medicine and agriculture), 3.4 Fungal symbioses: Mycorrhiza, Lichen and their importance.

(6 lectures)

4. Bryophytes

4.1 Salient features of Hepaticopsida, Anthocerotopsida and Bryopsida, 4.2. System of classification up to Class (Proskauer 1957), 4.3 Amphibian nature of bryophytes, 4.4 Economic and ecological importance.

(6 lectures)

5. Pteridophytes

5.1 Salient features of Psilophyta, Lycophyta, Sphenophyta and Filicophyta, 5.2 System of classification up to Division (Gifford & Foster 1989), 5.3 Economic importance (food, medicine & agriculture).

(6 lectures)

6. Gymnosperms

6.1 Salient features of Cycadophyta, Coniferophyta and Gnetophyta, 6.2 Outline classification up to Division: Progymnospermophyta to Gnetophyta (Gifford & Foster 1989), 6.3 Economic importance (wood, resin, essential oil & drugs). (6 lectures)

7. Angiosperms

7.1 Types and morphology of leaf, stem and root, 7.2 Inflorescence types with examples, 7.3 Flower: Different parts and forms of calyx, corolla, androecium and gynoecium; aestivation and placentation, 7.4 Types with examples-fruits and seeds. Brief idea about various modes of seed dispersal

(12 lectures)

PLANT DIVERSITY

BOT-H-CC1-1-P
Total marks 25; Credit 1, Class 30 hours

1. Work out: Morphology	**10 marks**
2. Identification with reasons (other groups except angiosperms)	**5 marks**
3. Class room performance (Practical notebook)	**3 marks**
4. Field notebook	**2 marks**
5. Viva-voce	**5 marks**

1. Flower- dissection, drawing and study
   a) Different parts, b) Adhesion and cohesion, c) Placentation, d) Aestivation
2. Study of ovules: types (Fresh specimens/ permanent slides/ photographs)
3. Fruits:different types- study from fresh/ preserved specimens
4. Inflorescence types: study from fresh/ preserved specimens

5. Identification on the basis of plant specimen, reproductive and structural features from preserved specimens/ permanent slides: Algae (*Nostoc*, *Oedogonium* and *Ectocarpus*), Fungi (*Rhizopus*, *Ascobolus* and *Agaricus*), Bryophytes (*Marchantia*, *Anthoceros* and *Funaria*), Pteridophytes (*Selaginella*, *Equisetum* and *Pteris*), Gymnosperms (male cone and female cone/ megasporophyll of *Cycas*, *Pinus* and *Gnetum*).
6. A field notebook supported with photographs ONLY taken during field study to be submitted giving comprehensive idea about different types of inflorescence, flowers, fruits and seed dispersal.

Textbook Reference:

1. Ganguli,H.C., Das, K.S.K. & Dutta, C.T. College Botany, Vol. I, latest Ed., New Central Book Agency

2. Ganguli,H.C. and Kar, A.K. College Botany, Vol. II, latest Ed., New Central Book Agency

3. Mukherjee, S. College Botany, Vol. III, latest Ed., New Central Book Agency

4. Uno, Storey& Moore, Principles of Botany, 2001, McGraw Hill.

5. Kenrick,P. & Crane, P. The Origin & early diversification of land plants (1997), Smithsonian Institute Press.

6. Bell, P.R. & Hensley, A.R. Green plants; their Origin & Diversity (2nd ed.), 2000, Cambridge University Press.

7. Frenchel, T. The origin & early Evolution of life, 2002, Oxford University Press.

8. Hait, G., Ghosh, A. and Bhattacharya, K. A Text Book of Botany (Vols. I, II & III), 2007, New Central Book Agency

9. Lock, A.J., & Evans, D.E., Plant Biology, 2001, Viva Books

10. Mitra, D., Guha, J. &Chowdhuri, S.K. Studies in Botany (Vols. I & II), Latest Ed., Das Printers

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

SEC

MUSHROOM CULTIVATION TECHNOLOGY (THEORY)

BOT-H-SEC-1-Th

Total marks 75; Credits 3, Class 45 hours

1. 1.1 Introduction, History of mushroom cultivation,1.2 Current overview of mushroom production in the world, 1.3 Mushroom biology-classification of mushrooms, edible mushrooms in India, poisonous mushrooms.

(6 lectures)

2. 2.1 Infrastructure-structural design and layout of mushroom farm, substrates (locally available), 2.2 Appliances- weighing balance, autoclave, laminar air flow, incubator,hot air oven, spirit lamp, bunsen burner, pH meter,laboratory heater, low-cost stoves, water bath, humidifier, water sprayer,vessels, inoculation hook and inoculation loop, sieves, culture racks,tray,polythene bags, 2.3 Methods of sterilization.

(9 lectures)

3. 3.1 Cultivation technology-overview of cultivation strategies,composting technology in mushroom production,mushroom bed preparation,culture media,pure culture, maintenance and preservation of pure culture, 3.2Production of spawn- cultivation of oyster mushroom, paddy-straw mushroom, milky mushroom and white button mushroom, 3.3 Cultivation of medicinal mushroom (Cordyceps and Ganoderma).

(12 lectures)

4. 4.1 Mushroom diseases and management strategies, 4.2 Post-harvest technology-short-term storage (Refrigeration- up to 24 hours), long-term storage (canning, pickles, papadsetc.), drying, storage in salt solutions, 4.3 Food preparations from mushrooms.

(9 lectures)

5. 5.1 Uses of spent mushroom substrate, 5.2Strain improvements in cultivated mushroom; Nutritional and medicinal value of edible mushrooms, 5.3 Research centres- National level and regional level, 5.4 Cost-benefit ratio, 5.5Mushroom based Industry, 5.6 Mushroom market in India and abroad.

(9 lectures)

MUSHROOM CULTIVATION TECHNOLOGY

BOT-H-SEC-1-P

Total marks 25; Credits 1, Class 30 hours

1.	Work out:	15 marks
2.	Class room performance (Practical notebook)	5 marks
3.	Viva-voce	5 marks

1. Macro identification of some common edible mushrooms (*Agaricus, Pleurotus,* Calocybe)
2. Media preparation and Fungal tissue culture
3. Sub-culturing for maintenance of culture
4. Spawn production
5. Cultivation of Pleurotus/Calocybe

Textbook Reference:

1. Acharya,K., Roy, A. &Sarkar, J. Mushroom Cultivation Technology, 2020, Techno World, Kolkata.
2. Marimuthu, T., Krishnamoorthy, A. S., Sivaprakasam, K. &Jayarajan, R. Oyster Mushrooms, 1991, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
3. Swaminathan, M. Food and Nutrition, 1990, Bappco, The Bangalore Printing & Publishing Co. Ltd.
4. Tewari, P. &Kapoor, S.C. Mushroom Cultivation, 1988, Mittal Publications, Delhi
5. Bahl, N. Handbook of Mushrooms, Ed. II, Vol I & Vol II

Semester 2

DSC/Core
PLANT SYSTEMATICS (THEORY)
BOT-H-CC2-2-T
Total marks 75; Credits 3, Class 45 hours

1. Introduction:

1.1 Components of Systematics: Nomenclature, Identification, Classification; 1.2. Taxonomy and its phases - Pioneer, Consolidation, Biosystematic and Encyclopaedic; alpha- and omega- taxonomy, Brief idea about the contributions by W. Roxburgh, N. Wallich, J D Hooker, CB Clarke, G King, K P Biswas 1.3 Nomenclature: Type method, Publication, Rank of taxa, Rules of priority, Retention and rejection of names, Author Citation, Effective and valid publication, Elementary knowledge of ICN-Principles. (10 lectures)

2. Systems of classification:

2.1 Broad outline of Bentham & Hooker (1862-1883) and Takhtajan (1997)- systems of classification with merits and demerits. Brief idea of angiosperm phylogeny group (APG IV classification), 2.2 Systematics in Practice: Herbaria and Botanic Gardens – their role in teaching and research; 2.3. Dichotomous keys – indented and bracketed. 2.4 Brief idea on Phenetics and cladistics: Monophyletic, polyphyletic and paraphyletic groups; Plesiomorphy and apomorphy; 2.5 Numerical taxonomy-methods and significance;

2.6 Data sources in Taxonomy: Supportive evidences from Phytochemistry, Cytology, anatomy and embryology (20 lectures)

3. Systematic study of angiosperm taxa: Diagnostic features, (Bentham & Hooker) and economically important plants (parts used and uses) of the following families:

3.1. Monocotyledons: Gramineae (Poaceae), Cyperaceae, Palmae (Arecaceae), Liliaceae, Musaceae, Zingiberaceae, Orchidaceae.

3.2. Dicotyledons: Magnoliaceae, Leguminosae (subfamilies), Euphorbiaceae, Malvaceae, Umbelliferae (Apiaceae), Labiatae (Lamiaceae), Cruciferae (Brassicaceae), Solanaceae, Scrophulariaceae, Acanthaceae, Rubiaceae, Cucurbitaceae, Compositae (Asteraceae). (15 lectures)

PLANT SYSTEMATICS

BOT-H-CC2-2-P

Total marks 25; Credit 1, Class 30 hours

1.	Work out on angiosperms	10 marks
2.	Spot Identification	3 marks
3.	Practical notebook	2 marks
4.	Field records (field notebook, herbarium specimens)	5 marks
5.	Viva-voce	5 marks

ANGIOSPERMS

1. Work out, description, preparation of floral formula and floral diagram, identification up to genus with the help of suitable literature of wild plants according to Bentham and Hooker system of classification from the following families: Malvaceae, Leguminosae (Papilionaceae), Solanaceae, Scrophulariaceae, Acanthaceae, Labiatae (Lamiaceae), Rubiaceae.

2. Spot identification (Binomial, Family) of common wild plants from families included in the theoretical syllabus.

FIELD WORK

1. Visit to Acharya Jagadish Chandra Bose Indian Botanic Garden (Shibpur, Howrah) and Central National Herbarium (CNH).
2. One Local and one long excursion in different phytogeographic zone or Two Local excursions.

FIELD RECORDS

1. Field Note Book (authenticated) with field notes on the plants of the area of excursion and voucher specimen book.

2. Herbarium specimens: Preparation of 15 angiospermic specimens (identified with author citation, voucher number and arranged following Bentham and Hooker system of classification) to be submitted during examination.

Textbook References:

1. Paria, N.D., Plant Taxonomy & Biodiversity, 2022, Santra Publication Pvt. Ltd.

2. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. and Donoghue, M.J. Plant Systematics, A Phylogenetic Approach (4th ed.), 2016, SinauerAssociaties, Inc.

3. Jones, S.B. and Luchsinger, A.E. Plant Systematics (2nd ed.), 1987, McGraw Hill Book Company

4. Singh, G. Plant Systematics: An Integrated Approach (3rd ed.), 2016, CRC Press

5. Sambamurty, A.V.S.S. Taxonomy of Angiosperms, 2005, I.K. International Pvt. Ltd.

6. Sivaranjan, V.V. Principles of Plant Taxonomy (2nd ed.), 1991, Oxford & IBH

7. Subrahmanyam, N.S. Modern Plant Taxonomy, Latest Ed., Vikas Publishing House

8. Naik, V.N. Taxonomy of Angiosperms, Latest Ed., Tata McGraw Hill

9. Stace, C. A Plant Taxonomy & Biosystematics, Latest Ed., Arnold Publishers

10. Mitra, J.N. An Introduction to Systematic Botany & Ecology, Latest Ed., World Press

11. Dutta, S.C. Systematic Botany, Latest Ed., Wiley Eastern.

12. Lawrence, G.H.M. Taxonomy of Vascular Plants Ed., Oxford & IBH.

13. Prain, D. Bengal Plants (Vol I & II), Bishen Singh Mahendra Pal Singh.

14. Jeffrey, C. An Introduction to Plant Systematics, Latest Ed., Allied Publishers Pvt. Ltd.

15. Radford. A.B. Fundumentls of Plant Systematics, Latest Ed., Harper & Row.

16. Simpson, G. Plant Systematics, 2006, 2010, 2019, Springer.

17. Bhattacharya, B. Systematic Botany, 2006, Narosa Publishing House.

18. Heywood, V.H. Plant Taxonomy 1967, Edward Arnold, London.

19. Cronquist, A. The Evolution & Classification of Flowering Plant, 1988 (2nd ed.), New York Bot. Garden Bronx. New York.

20. Cronquist, A. An Integrated System of Classification of Flowering Plants.1981. Bishen Singh Mahendra Pal Singh.

21. Subramanyam, N.S. Laboratory Manual of Plant Taxonomy (2nd ed.) 1999, Vikas Publishing House.

22. Heywood, V.H. Flowering Plants of the World 1978, Oxford University Press.

SEC
BIOFERTILIZERS AND BIOPESTICIDE
BOT-H-SEC-2-T
Total marks 75; Credits 3, Class 45 hours

1. 1.1 General account and components of organic farming; microbes used as biofertilizers, general account on mass production of biofertilizers; 1.2 Manure- Green manuring and organic fertilizers;types and methods of composting; vermicompost and field applications; recycling of biodegradable municipal, agricultural and industrial wastes. (6 lectures)

2. Nitrogen fixing bacteria as biofertilizers: 2.1 Rhizobium- Isolation, identification, mass multiplication, carrier-based inoculant formulation, filed application; 2.2 Azospirillum- Isolation, carrier-based inoculants, mass multiplication, associative effect of different microorganisms; 2.3 Azotobacter- Classification, characteristics, crop response to Azotobacter inoculants, maintenance and mass multiplication. (9 lectures)

3. 3.1 Cyanobacteria (Blue green algae), Azolla and Anabaena azollae association, nitrogen fixation,factors affecting growth, blue green algae and Azolla in rice cultivation. 3.2 Actinorhizal symbiosis- Actinorhizal plants, infection process, isolation of Frankia. (6 lectures)

4. Mycorrhizal association- 4.1 Types of mycorrhizal association, phosphorus nutrition, growth and yield; 4.2 colonization of VAM – isolation and inoculum production of VAM and its influence on growth and yield of crop plants. (6 lectures)

5. 5.1 Phosphate, Potash and Zinc Solubilizing Microbes- Isolation, characterization, mass production, field application; 5.2 Plant Growth Promoting Rhizobacteria (PGPR) as biofertilizers, mode of action of PGPR. (6 lectures)

6. Biopesticides – 6.1 Introduction; General features of potential biopesticides; Prospect and limitation; 6.2 Trichoderma: Isolation, mass production, formulation, quality control and field application; 6.3 Pseudomonas- Isolation, beneficial Pseudomonas strains in agriculture, mode of action; 6.4 Fungi as bioinsecticide- Metarhizium anisopliae, Beauveria bassiana and Verticillium lecanii-overview, mode of action and use in agriculture; 6.5 Nematophagous fungi-overview, mode of action; 6.6 Bacteria as bioinsecticide- Bacillus thuringiensis -Characterization, mass production and field application; 6.7 Virus as bioinsecticide- Baculovirus- characterization, bioformulation, mass production and field application. (12 lectures)

BIOFERTILIZERS AND BIOPESTICIDES
BOT-H-SEC-2-P
Total marks 25; Credit 1, Class 30 hours

1.	Work out:	15 marks
2.	Class room performance (Practical notebook)	5 marks
3.	Viva-voce	5 marks

1. Isolation and identification of phosphate-solubilizing fungi.
2. Study of Arbuscular Mycorrhizal fungi.
3. Isolation of Azotobacter and Trichoderma from the soil.
4. Evaluation of in vitro antagonistic activity of Trichoderma species in the dual culture system.

Textbook reference

1. Acharya, K., Sen, S. & Rai, M. Biofertilizers and Biopesticides, 2019, Techno World, Kolkata.
2. Sathe,T.V. Vermiculture and Organic Farming 2004. Daya Publishers.
3. Subha Rao, N. S. Soil Microbiology, 2000, Oxford & IBH Publishers, New Delhi.
4. Vayas, S.C. Vayas, S. & Modi, H.A Bio-fertilizers and organic Farming, 1998, Akta Prakashan, Nadiad
5. Kannaiyan, S. Biotechnology of Biofertilizers, 2003, CHIPS, Texas.
6. Rai, M.K. Hand book of Microbial Biofertilizers, 2005, The Haworth Press, Inc. New York
7. Sahayaraj, K. Basic and Applied Aspects of Biopesticides, Springer India, 2014
8. Bailey, A. Chandler, D. Grant, W.P. Greaves, J. Prince, G. Biopesticides- Pest Management and Regulation, CABI, 2010
9. Kaushik, B. D. Kumar, D. Shamim, M. Biofertilizers and Biopesticides in Sustainable Agriculture, Apple Academic Press, 2019

IDC in BOTANY (To be opted in 1st or 2nd or 3rd semester)

PLANTS AROUND US (THEORY)

Total marks 50; Credits 2, Class 30 hours

Introduction: Introduction to plant groups: Algae, Bryophytes, Pteridophytes, Gymnosperms, Angiosperms (Monocot and Dicot); Fungi -general characters; Contributions of Theophrastus, Charak, Sushruta, Linnaeus, Mendel and J.C. Bose. ……..5 lectures

Plant body: Plant cell and tissue; Morphology of root, stem, leaf, flower, fruit and seed. ..…5 lectures

Plants and ecosystem: Phytodiversity and conservation; Biodiversity hotspots of India; Forest types in India; Plant-based adaptations to climate change; Concept of 'Carbon footprint'- role of plants in reducing carbon footprint. ……..5 lectures

Plants and society: Plants in day-to-day life (brief general information including uses)-major cereals (rice, wheat and maize); pulses (mung and pea); Oil (mustard and coconut); Sugar (sugarcane and beet root); Vegetables (potato, brinjal, ladies finger and spinach); Fruits (apple, banana, guava, mango and jackfruit); Beverages (tea, coffee, beer and wine); Plants as timber (sal and teak); Non-timber- energy (fossil and non-fossil), resin, honey and essential oil (lavender and citronella oil); Fiber (jute and cotton); Ornamental plants (rose, marigold, tuberose, gulmohar, jarul, kalanchoe); Importance of bacteria *(Lactobacillus, E. coli* and *Rhizobium)* and Fungi *(Phytophthora, Agaricus* and *Penicillium).* …..10 lectures

Plants and human health: Important medicinal plants and their uses- basak *(Justicia adhatoda),* ghritakumari *(Aloe vera),* cinchona *(Cinchona officinalis),* neem *(Azadirachta indica),* kalmegh *(Andrographis paniculata),* pudina *(Mentha arvensis),* tulsi *(Ocimum sanctum),* sarpagandha *(Rauvolfia serpentina);* Plant-derived medicinal compounds and uses (Quinine, Reserpine, Vincristine, Curcumin, Gingerol). …….5 lectures

Plants Around Us

Total marks 25; Credit 1, Class 30 hours

1.	Workout: Dissection of plants	10 marks
2.	Spot Identification	6 marks
3.	Practical notebook	4 marks
4.	Viva-voce	5 marks

- Identification: Morphological study of plant specimens
- Microscopic study - *Nostoc*, *Oedogonium* (with oogonium), *Rhizopus, Penicillium* (sporangiophore). Macroscopic study - *Agaricus* (fruit body), *Marchantia* with gemma cup, antheridiophore/ archaegoniophore, Moss sporophyte, *Pteris* (fertile leaf/pinna), *Pinus* - male and female cone.
- Fruits of tomato, peas, cucumber, citrus, apple & banana.
- Work out of flower: Floral parts of *Hibiscus rosa-sinensis, Clitoria ternatea* & *Datura metel.*

Textbook references:

1. Studies in Botany (vol-I)- J.N.Mitra, Debabrata Mitra & Salii Chowdhury (Moulik Library)
2. A Textbook of Botany (Vol. 1)- G. Hait, K. Bhattacharya & A. K. Ghosh (New Central Book Agency)
3. Udvid Bigyan (Vol-I) (Bengali)- S. Chowdhury, N. Datta, D. Mitra & J. Guha (Moulik Library)
4. College Botany (vol 11)-H.C. Gangulee, A.K. Kar, S.C. Santra (New Central Book Agency)
5. Snatak Udvidbidya (Semester 1)- Dr. Jayanta Kumar Sikdar, Dr. Kunal Sen, Dr. Pranab Giri (Santra Publication)

Semester 3

ECONOMIC BOTANY

BOT-H-CC3-3-T

(Total Marks 75, Credits 3, Lectures 45 hours)

1. **Origin of cultivated crops:** Concepts of centre of origin, their importance with reference to Vavilov's work. Examples of major plant introductions; crop domestication and loss of genetic diversity; evolution of new crops/ varieties, importance of germplasm diversity. **4 Lectures**

2. Cereals, pulses, oils and rubber:

Cereals: Rice, Wheat, (cultivation, processing and uses), Millets as future cereals. Pulses and Legumes: Cultivation and uses of Gram, and Soyabean, Oil and fats: Extraction, uses and health implications of Mustard, Groundnut, Sunflower, Coconut (Botanical name, family and uses). Essential oils- general account, extraction methods, comparison with fatty oils and their uses,4 Rubber yielding plants: Para-rubber (*Hevea brasiliensis*), Assam rubber (*Ficus elastica*)- tapping, processing and uses, Other natural rubber: Sources (Ceara rubber, Castilla rubber, Lagos silk rubber, Landolphia rubber, Guayule rubber, Dandelion rubber). **12 Lectures**

3. **Sugar, starch, spices and beverages:**

Processing of sugarcane to products and byproducts. Extraction/processing from, Sugar beet,. Spices and condiments: Scientific names, family, economically important parts and uses of Ajwain, Cumin, Black Cumin, Mustard, Fenugreek, Coriander, Chillies, Bay leaf, Black Pepper, Cardamom (small and big), Clove, Turmeric, Cinnamon, Onion, Garlic and Ginger, Beverages: Tea and coffee (plant habit, processing and uses). **9 Lectures**

4. **Narcotics, timbers and fibres:**

Habit forming drugs with special reference to Poppy, *Cannabis* and Tobacco (processing, uses and health hazards), Timber: General account with special reference to Sal, Teak, Mahogany and Sissoo, Fibers: Classification on the basis of origin of fibres, Cotton, Flax and Jute (extraction and uses). **16 lectures**

5. Vegetables and fruits:

Vegetables: Scientific names, family and edible parts- Potato, Pointed gourd, Brinjal, Tomato, Cauliflower, Cabbage, Lady´s finger, Ridge gourd, Cucumber, Spinach, Carrot, Pea, Beans, Drumstick, Radish and Sweet potato, Fruits: Scientific names,

family, types of fruits and edible parts: Mango, Papaya, Custard apple, Pineapple, Tamarind, Jackfruit, Banana, Guava, Pomegranate, Apple, Strawberry, Wood apple, Litchi and Grapes. **4 Lectures**

ECONOMIC BOTANY

BOT-H-CC3-3-P

(Total Marks 25, Credits 2, Class 30 hours)

1. Identification (2× 6)	**12 marks**
2. Practical notebook	**4 marks**
3. Field notebook	**4 marks**
4. Viva voce	**5 Marks**

1. Identification of economically important plants (as listed below) from fresh/ herbarium sheets/ preserved specimens:

Cereals: Rice and Wheat

Legume: Gram, and Soybean (habit, fruit and seed structure) Spices and condiments: Coriander, Cumin, Bay leaf, Black pepper, Cinnamon

Common vegetables: Potato, Cucumber, Brinjal, Lady´s finger, Carrot, Sweet potato Fruits (only identify the type of fruit) as listed in theoretical syllabus

Fibres: jute and cotton (plant and parts used).

2. Local Field visit to give an idea about cultivation of any one available crop
3. Field record must be properly authenticated by escorting teacher and supported by photographs of the field

Textbook:

1. Mukherjee, S. College Botany, Vol. III, latest Ed., New Central Book Agency
2. Mitra, D., Guha, J., Chowdhuri, S.K. Studies in Botany, Vol. II, latest Ed. D.N. Moulik for Moulik Library.
3. Kochhar, S.L. 2012. Economic Botany in Tropics, MacMillan & Co. New Delhi, India.
4. Simpson, B.B. and Conner-Ogorzaly, M. 1986. Economic botany: plants in our world.
5. Albert F. Hill 1952. Economic botany: a textbook of useful plants and plant productions, 2nd Edn.

PLANT ANATOMY & EMBRYOLOGY
BOT-H-CC4-3-T

(Total Marks 75, Credits 3, Lectures 45 hours)

PLANT ANATOMY (50 marks)

1. Cell and Tissues: 14 lectures

1.1 Cell wall: ultrastructure, chemical constituents; thickening of cell wall.

1.2 Tissues: meristems, simple and complex tissues, cambium- Structure and function

1.3 Mechanical tissues and the principles governing their distribution in plants.

1.4 Stele: stelar types; leaf-trace and leaf-gap, 1.5 Stomata: origin and types (Metcalfe and Chalk, 1950; Stebbins and Khush, 1961).

2. Primary and secondary growth: 8 lectures

2.1 Primary structure of stem and root- monocot and dicot. Leaf- dorsiventral and isobilateral, 2.2 Secondary growth: normal (intra- & extra-stelar), anomalous (stem of *Bignonia*, *Boerhavia*, *Tecoma*, *Dracaena* and root of *Tinospora*).

3. Developmental and Ecological Anatomy: 6 lectures

3.1 Organisation of shoot apex (Tunica–Corpus) and root apex (Korper-Kappe), plastochron,

3.2 Adaptive anatomical features of hydrophytes, xerophytes, halophytes.

4. Scope of plant anatomy: 2 lectures

Application in systematics, forensics and pharmacognosy, brief idea on dendrochronology.

EMBRYOLOGY (25 marks)

1. Pre-fertilisation and post- fertilization changes : 10 lectures

1.1. Microsporogenesis and Microgametogenesis, 1.2. Megasporogenesis and Megagametogenesis (monosporic, bisporic and tetrasporic), 1.3 Pollen germination, 1.4 Pollen tube- growth, entry into ovule and discharge, 1.5 Double fertilization, post-fertilization changes.

2. Embryo development and apomixis: 5 lectures

2.1 Embryogenesis in *Capsella*, 2.2 Development of endosperm (3 types), 2.3 Apomixis- Apospory and Apogamy, 2.4 Polyembryony- different types.

PLANT ANATOMY& EMBRYOLOGY

BOT-H-CC4-3-P

Total Marks 25; Credit 1, Class 30 hours

1. Workout on Plant Anatomy Embryology	**10 marks**
2. Identification with reasons	**5 marks**
3. Classroom performance: Lab records	**5 marks**
4. Viva– voce	**5 marks**

PLANT ANATOMY

1. Microscopic studies on: Types of stomata, sclerenchyma and parenchyma cells, sclereids, raphides (*Colocasia*), cystolith (*Ficus* leaf) starch grains, aleurone grains, laticiferous ducts, oil glands.

2. Study of anatomical details through permanent slides/ temporary stained mounts- a) Root-Monocot and dicot, b) Stem- Monocot and dicot, c) Leaf- Isobilateral and Dorsiventral, d) Stelar types.

3. Study of anomalous secondary structure in stem of *Bignonia*, *Boerhaavia*, *Tecoma*, *Dracaena* and root of *Tinospora*

4. Study of adaptive anatomical features: Hydrophytes (*Nymphaea* – petiole), Xerophytes (*Nerium* – leaf) and Halophytes (*Aegiceros corniculata*- salt gland), Epiphytic root (Orchid - velamen).

EMBRYOLOGY

1. Female gametophyte: Polygonum (monosporic) type of Embryo sac (Permanent slides/photographs).
2. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ campylotropous
3. Pollination types and seed dispersal mechanisms (including appendages, aril, caruncle) Photographs/specimens).
4. Dissection of embryo/endosperm from developing seeds

Textbook References:

PLANT ANATOMY

1. Fahn, A. Plant Anatomy (4th ed.), 1990, Wiley Eastern.

2. Eames, A.J. & Mac. Daniels, L.H. An Introduction to Plant Anatomy, Latest Ed., McGraw

Hill
3. Esau, K. Anatomy of Seed Plants (2nd ed.), 1977, John Wiley & Sons
4. Pandey, B.P. Plant Anatomy, Latest Ed., S. Chand & Company
5. Tayal, M.S. Plant Anatomy, Latest Ed., Rastogi Publications
6. Roy, P. Plant Anatomy, Latest Ed., New Central Book Agency
7. Morphology and Taxonomy of Angiosperms
8. Singh, G. Plant Systematics: An Integrated Approach (3rd ed.), 2016, CRC Press
9. Sambamurty, A.V.S.S. Taxonomy of Angiosperms, 2005, I.K. International Pvt. Ltd.
10. Sivaranjan, V.V. Principles of Plant Taxonomy (2nd ed.), 1991, Oxford & IBH
11. Subrahmanyam, N.S. Modern Plant Taxonomy, Latest Ed., Vikas Publishing House
12. Naik, V.N. Taxonomy of Angiosperms, Latest Ed., Tata McGraw Hill
13. Stace, C. A Plant Taxonomy & Biosystematics, Latest Ed., Arnold Publishers
14. Mitra, J.N. An Introduction to Systematic Botany & Ecology, Latest Ed., World Press
15. Dutta, S.C. systematic Botany, Latest Ed., Wiley Eastern.
16. Lawrence, G.H.M. Taxonomy of Vascular Plants Ed., Oxford & IBH.
17. Prain, D. Bengal Plants (Vol I & II), Bishen Singh Mahendra Pal Singh.
18. Jeffrey, C. An Introduction to Plant Systematics, Latest Ed., Allied Publishers Pvt. Ltd.
19. Radford. A.B. Fundumentls of Plant Systematics, Latest Ed., Harper & Row.
20. Paria, N.D. and Chattopadhyay, S.P. Flora of Hazaribagh District, Bihar, 2000 & 2001, Vol I & II, BSI, Kolkata 16. Simpson, G. Plant Systematics, 2006, Springer.
21. Bhattacharya, B. Systematic Botany, 2006, Narosa Publishing House.

EMBRYOLOGY

1. Raghavan, V. Molecular Embryology of Flowering Plants, 1997, Camb. University Press.
2. Maheswari, P. An Introduction to Embryology of Angiosperm, Latest Ed., Tata McGraw Hill.
3. Raghavan, V. Embryogenesis in Angiosperms: A Development & Experimental Study, 1986, Cambridge University Press.
4. Bhojwani, S.S. & Bhatnagar, S.D. The Embryology of Angiosperms (4th ed.), 1989, Publishing House.

PLANT TISSUE CULTURE AND HORTICULTURE PRACTICES
BOT-H-SEC-3-T

(Total Marks 75, Credits 3, Lectures 45 hours)

A. Plant Tissue Culture (50 marks)

1. Plant Tissue Culture: 3 Lectures

Land mark contributions, Importance of plant tissue culture as tools for fundamental and applied plant sciences, Future prospects in improving cash crops, medicinal plants and forest trees.

2. Requisites of Plant Tissue Culture and Plant regeneration: 8 Lectures

Requirement of plant tissue culture laboratory- Equipment, instruments, glassware and plastic wares, Aseptic technique- contaminants and sterilization, Plant tissue culture medium: media preparation (basal medium), gelling agents and their uses, Use of plant growth regulators in plant tissue culture, Cellular totipotency, Organogenesis (direct and indirect), Somatic embryogenesis and its significance, Artificial seed (encapsulation and its potential uses).

3. Types of culture techniques: 13 Lectures

Plant micropropagation**:** Methods and advantages of micropropagation, Steps of general micropropagation, Important considerations and precautions, Somaclonal variation: Types, applications of tissue culture-derived variation and crop improvement, Callus and haploid culture: Callus culture- Induction, maintenance and application, Suspension culture (introductory idea), Haploid culture- Anther, pollen and ovary culture methods, application and utilization of haploids in agriculture Protoplast culture- isolation and culture, protoplast fusion (somatic hybridization), cybrid production, application, Embryo and endosperm culture- procedure and application.

4. Production of useful metabolites by tissue culture techniques: 6 Lectures

Secondary metabolites: Techniques of production of secondary metabolites; terpenes, phenolics and alkaloids- definitions and functions, Valuable natural compounds from plant cell and tissue culture and their uses as drugs- brief idea.

B. Horticulture Practices (25 marks)

1 Horticulture: 4 Lectures

Scope, importance and branches, Role in rural economy and employment generation,

Harvesting and handling of fruits, vegetables and cut flower; methods of preservation and processing,

Urban horticulture and ecotourism.

1. Horticultural techniques: 3 Lectures

Pruning, Grafting, layering, pinching, disbudding, desuckering, staking and netting. mulching, Hydroponics. sexual (seed production), scope and limitations. Application of manures, fertilizers, nutrients and PGRs, Weed controls, biofertilizers, biopesticides, irrigation methods,

2. Ornamental plants: 5 Lectures

Types, classifications (annuals, perennials, climbers and trees), Identification and salient features of Some ornamental flowers (rose, marigold, gladiolus, carnations, gerberas, tuberose, desert rose), Ornamental flowering trees (Indian laburnum, gulmohar, jacaranda, jarul, fishtail palm, simul, coral tree), Bonsai and their commercial use, Importance of flower shows and exhibitions

3. Fruit and vegetable crops: **3 Lectures**

Some common fruits and vegetables- description of plants and their economically important parts (orange, banana, mango, papaya, guava, litchi, wood apple , potato, cauliflower, carrot, onion, peas, brinjal, ridged gourd), Fruit processing- scope and benefit.

PLANT TISSUE CULTURE AND HORTICULTURE PRACTICES

BOT-H-SEC-3-P

Total marks- 25; Credit 1, Class 30 hours

1. Experiment/ Work out/ Demonstration	**10 marks**
2. Identification (ornamental flowers)	**5 marks**
3. Practical notebook	**5 marks**
4. Viva-voce	**5 marks**

1. Media preparation and aseptic inoculation of explant for seed culture.
2. Propagation of two horticulturally important plants (each student needs to propagate

plants following two separate vegetative methods; records and photographs to be authenticated by respective teacher)

3. Identification of locally available ornamental flowers as per theory syllabus

Textbook references:

PLANT TISSUE CULTURE

1. Chawla, H.S. An Introduction to Plant Biotechnology (2nd ed.), 2002, Oxford & IBH

2. Borer, A., Sentos, F.R. & Bowen, D.B. Understanding Biotechnology, 2003, Pearson Education

3. Ingacimuthu, S. Plant Biotechnology, 1997, Oxford & IBH

4. Walker, J.M. & Rapley, R. Molecular Biology & Biotechnology, 2000, Royal Society of Chemistry

5. Gamorgs, O.L. & Phillips, G.C. Plant Cell, Tissue and Organ Culture: Fundamental method, Narosa Publishing House

6. Dubey, R.C. Biotechnology, Latest Ed., S.Chand& Company Pvt. Ltd.

7. Bhojwani, S.S. & Razdan, M.I. Plant Tissue Culture: Theory and Practise, Elsevier

8. Rajdan, M.K. An Introduction to Plant Tissue Culture, Latest Ed., Oxford & IBH

9. Jha, T.B. & Ghosh, B. Plant Tissue Culture, 2003, Universities Press

10. Mascarenhas, A.F. Handbook of Plant Tissue Culture, ICAR

11. Kar, D.K. & Halder, S. Plant Breeding, Biometry & Biotechnology, 2010, New Central Book Agency

12. Slatter, A., Scott, N. & Fowler, N. Plant Biotechnology, 2003, Oxford University Press

HORTICULTURE

1. Singh, D. &Manivannan, S. 2009. Genetic Resources of Horticultural Crops. Ridhi International, Delhi, India.

2. Swaminathan, M.S. and Kochhar, S.L. 2007. Groves of Beauty and Plenty: An Atlas of Major Flowering Trees in India. Macmillan Publishers, India.

3. NIIR Board 2005. Cultivation of Fruits, Vegetables and Floriculture. National Institute of Industrial Research Board, Delhi.

4. Kader, A.A. 2002. Post- Harvest Technology of Horticultural Crops. UCANR Publications, USA.

5. Capon, B. 2010. Botany for Gardeners. 3rd Edition. Timber Press, Portland, Oregon.

Semester 4

PHYCOLOGY

BOT-H-CC5-4-T

(Total Marks 75, Credits 3, Lectures 45 hours)

Unit I

General account:

Thallus organization and evolutionary trend in algal members of different groups, structure of algal cell, pigment types and variation. Ultrastructure of flagella and chloroplast, Process of reproduction in algae: Isogamy, Anisogamy, Oogamy- *Chlamydomonas*, *Oedogonium*, *Vaucheria*, Conjugation- *Spirogyra*, Life cycle pattern in algae- Haplontic: *Chara*, Diplontic: *Fucus*, Haplo-diplontic (Isomorphic): *Ectocarpus*, Haplo- diplontic (Heteromorphic): *Laminaria*, Triphasic: *Polysiphonia*, Significant contributions of some phycologists (F. E. Fritsch, G. M. Smith, R. N. Singh, T.V. Desikachary, H.D. Kumar, M.O.P. Iyengar) **16 Lectures**

Unit II

Classification:

Classification by Lee (2018) upto phylum with examples, Cyanophyta (emphasis on cell ultrastructure, reproduction, structure and function of heterocyst), Rhodophyta, Chlorophyta (emphasis on phylogenetic significance of flagellar ultrastructure), Charophyta, Heterokontophyta (Phaeophyceae, Xanthophyceae; Bacillariophyceae - emphasis on cell structure, cell division, auxospore formation). **15 Lectures**

Unit III

Algal Ecology:

Role of phytoplanktons in aquatic ecosystem, Algae in CO_2 sequestration, Phytoremediation by algae. **7 Lectures**

Algal Biotechnology:

Algal culture and cultivation (Photobioreactor), Algae as food, biofuel and biofertilizer. **7 Lectures**

PHYCOLOGY

BOT-H-CC5-4-P

(Total Marks 25, Credit 1, Class 30 hours)

1. Work out	**10 marks**
2. Identification with reasons	**6 marks**
3. Practical notebook	**4 marks**
4. Viva- voce	**5 marks**

1. Workout of the following algae with reproductive structure (Free hand drawing and drawing under drawing prism with magnification): *Spirogyra*, *Oedogonium*, *Chara*, *Ectocarpus.*

2. Study of (a) Permanent slides: *Nostoc, Gloeotrichia, Volvox, Vaucheria, Coleochaete, Polysiphonia,* Centric and Pennate diatom*;* (b) Macroscopic specimen: *Sargassum.*

Textbook References:

1. Kumar, H.D. 1999. Introductory Phycology (2nd ed.), Affiliated East-West Press Pvt. Ltd.

2. Lee, R.E. 2018. Phycology (5th ed.), Cambridge University Press

3. Vashishta, B.R., Sinha, A.K. & Singh, V.P. 2002. Algae (9th ed.), S. Chand & Company

4. Sambamurty, A.S.S. 2005. A text book of Algae, I.K. International Pvt. Ltd. 22

5. Graham, L.E. & Wilcox, L.W. 2000. Algae, Prentice Hall

6. Smith, G.M. 1955. Cryptogamic Botany, Vol. 1 (2nd ed.), McGraw Hill

7. Prescott, G.W. 1969. Algae: A Review, Bishen Singh Mahendra Pal Singh

8. Fritsch, F.E. 1936. The Structure & Reproduction of Algae, Vols. I & II, Cambridge University Press

9. Van Den Hoek, D.G. Mann, H.M. Jahns. 1996. Algae: An Introduction to phycology, Cambridge University Press

BOT-H-CC6-4-T

ARCHAEGONIATES

(Total Marks 75, Credits 3, Lectures 45 hours)

BRYOPHYTES (25 marks)

1. Introduction to Monosporangiophyta (Bryophytes):

1.1 Unifying features of archaegoniates; transition to land habit, 1.2. Origin of Alternation of Generations (Homologous and Antithetic theory), 1.3 Evolution of sporophytes (Progressive and Regressive concept), 1.4 Origin of bryophytes, 1.5 Bryophytes as bio indicators of pollution**4 Lectures**

2 Classification :

2.1. Classification (Crandall-Stotler et al, 2009; Renzaglia et al, 2009,Goffinet et al, 2009;) up to class with diagnostic characters and examples. **2 Lectures**

3. Life History: Gametophyte structure and reproduction, development and structure of sporophyte, spore dispersal in: 3.1 *Riccia*, 3.2 *Marchantia*, 3.3.*Anthoceros*, 3.4.*Funaria.*

4 Lectures

PTERIDOPHYTES (25 marks)

1. General Account:

1.1. Colonisation and rise of early land plants, 1.2 Origin and evolution of stellar structure,

1.3 Economic importance. **3 Lectures**

2. Life History:

Sporophyte structure, reproduction and structure of gametophyte in 2.1. *Psilotum*, 2.2. *Lycopodium*, 2.3. *Selaginella*, 2.4. *Equisetum*, 2.5. *Pteris*, 2.6.*Marsilea*. **6 Lectures**

3. Telome concept and its significance in the origin of different groups of Pteridophytes.

4 Lectures

Heterospory and origin of seed habit. **2Lectures**

4. GYMNOSPERMS (25 marks)

1. **Progymnosperms :**

Diagnostic characters of the group, 1.1.Vegetative and reproductive features of *Archaeopteris*, 1.2. Phylogenetic importance. **6 Lectures**

2. **Life History :**

Distribution in India; vegetative, anatomical and reproductive structures of sporophyte, development of gametophyte in : 2.1. *Cycas*, 2.2. *Pinus*, 2.3. *Ginkgo* and *Gnetum*. **10 Lectures**

3. Pollination and Embryogeny of gymnosperms **2 Lectures**
4. Phylogeny: Evolutionary significance of gymnosperms **2 Lectures**

ARCHAEGONIATES

BOT-H-CC6-4-P

Total Marks 25; Credit 1, Class 30 hours

1. Workout on Pteridophytes **7 marks**

2. Identification with reasons (Permanent slides/samples Bryophytes, Pteridophytes and Gymnosperms) **9 marks**

3. Classroom performance: (Lab records) **4 marks**

4. Viva **5 marks**

BRYOPHYTES

1. Study from permanent slides: *Riccia* (V.S. of thallus with sporophyte), *Marchantia* (L.S. through gemma cup, antheridiophore, archegoniophore, sporophyte), *Anthoceros* (L.S. of sporophyte), *Funaria* (L.S. of capsule).

PTERIDOPHYTES

1. Morphological study of the sporophytic plant body: *Psilotum, Lycopodium, Ophioglossum* and *Marsilea*.

2. Work out of the reproductive structures: *Lycopodium, Selaginella, Equisetum, Pteris*.

3. Study from permanent slides: *Psilotum* (T.S. of synangium), *Ophioglossum* (L.S. of spike), *Dryopteris* (sorus and gametophyte), *Marsilea* (L.S. of sporocarp).

GYMNOSPERMS

1. Study from permanent slides: T.S. of leaf and wood anatomy of *Cycas* and *Pinus*, *Cycas* (L.S. of ovule), *Pinus* (L.S. of male and female cone), *Ginkgo* (L.S. of female strobilus), *Gnetum* (L.S. of male cone and ovule).

Textbook References:

Bryophytes

1. Parihar, N.S. Introduction to Embryophyta (Vol. 1 Bryophyta), Central Book Distributors
2. Shaw, A. J. & Bernard, G. 2009. Bryophyte Biology, Cambridge University Press
3. Rashid, A. 1998. An Introduction to Bryophyta, Vikas Publishing House
4. Chopra, R.N. & Kumar, P.K. Biology of Bryophyta, Latest Ed., Wiley Eastern
5. Puri, P. Bryophyte, Latest Ed., Atmaram& Sons
6. Vashista, B.R. Bryophyta, Latest Ed., S. Chand & Company

Pteridophytes

1. Spore, K.R. The Morphology of Pteridophyte, Latest Ed.,Huchinson& Co. Ltd.
2. Rashid, A. An Introduction to Pteridophyte, Latest Ed., Vani Educational Books.
3. Vashista, P.C. Pteridophyta, Latest Ed., S. Chand & Company Pvt. Ltd.
4. Gifford, E. M. & Foster, A. S. 1998. Morphology & Evolution of Vascular Plants (3rd ed.), Freeman and Co.

9. Gymnosperms

1. Sporne, K.R. The Morphology of Gymnosperms, Latest Ed., Hutchinson &Co. Ltd.
2. Vashishta, P.C. Gymnosperm, Latest Ed., S. Chand & Company Pvt.
3. Karkar, R.K. &Karkar, R. The Gymnosperms, Latest Ed.
4. Bhatnagar, S.P. &P.Moitra, 1997. Gymnosperm, New Age International
5. Biswas, C. &Johri, P.M. 1997. The Gymnosperm, Narosa Publishing House
6. Dutta, S.C. 1984. An Introduction to Gymnosperms (3rd ed.), Kalyani Publishers
7. Gifford, E.M. and Foster, A.S. 1989. Morphology & Evolution of Vascular Plants (3rd ed.), Freeman & Co.

PALAEOBOTANY AND PALYNOLOGY

BOT-H-CC7-4-T

(Total Marks 75, Credits 3, Lectures 45 hours)

PALAEOBOTANY (50 marks)

1. Geological time scale with dominant plant groups through ages and major important evolutionary events (development of vascular tissue, origin of roots, and leaves and seeds) **4 lectures**

2. Plant Fossil :

2.1. Types: Body fossil (micro- and megafossils), Trace fossil, Chemical fossil, Index fossil, 2.2. Different modes of preservation (Schopf, 1975), 2.3. Conditions favouring fossilization, 2.4. Nomenclature and Reconstruction, 2.5. Principle of fossil dating (a brief idea), 2.6. Relative (biostratigraphy and index fossil) and Absolute dating (^{238}U-^{206}Pb, ^{14}C Method), 2.7. Importance of fossil study. **8 lectures**

3. Fossil Pteridophytes :

Structural features, geological distribution and evolutionary significance of 3.1. *Rhynia*, 3.2. *Lepidodendron* (Reconstructed), 3.3. *Calamites* (Reconstructed). **6 lectures**

4. Fossil Gymnosperms:

Structural features and geological distribution of reconstructed genera: 4.1. *Lyginopteris*, 4.2. *Williamsonia*, 4.3.*Cordaites* **6 lectures**

5. Indian Gondwana System – Brief idea of Gondwana; Three fold division of Indian Gondwana with major megafossil assemblages. **4 lectures**

PALYNOLOGY (25 marks)

6. Introduction, 6.1 Pollen and non-pollen palynomorphs (spores and phytoliths), types of phytoliths, 6.2. Pollen aperture types, 6.3. NPC classification (Erdtman). 6.4. Pollen wall- sporopollenin, tratification and ornamentation (sculpturing).

5 lectures

7. Applied Palynology:

Basic concepts of: 7.1. Palaeopalynology (definition, role of fossil spore/ pollen/ phytolith in vegetation and climate reconstruction), 7.2. Aeropalynology- basic mechanism of spore/pollen allergy, 7.3 Common spore/pollen allergies, pollen calendar 7.4 Aeroallergens-common pollen-allergy causing plants of India, 7.5 Forensic palynology- definition, sources of pollen as forensic evidence–7.6 Applications and limitations of forensic palynology, 7.7 Pollination biology and melissopalynology- types of pollination, pollinator groups, pollen-pistil interactions and its significance; common Indian bee plants, types of honey, botanical and geographical origin of honey, absolute pollen count;.

12 lectures

PALAEOBOTANY AND PALYNOLOGY

BOT-H-CC7-4-P

(Total Marks 25, Credit 1, Class 30 hours)

1. Morphological study of mega fossils	**6 marks**
2. Identification with reasons from permanent preparations (Anatomy + Pollen)	**3+3= 6 marks**
3. Palynological study	**5 marks**
4. Classroom performance: (Lab records)	**3 marks**
5. Viva- voce	**5 marks**

1. Morphological study: *Ptilophyllum* and *Glossopteris* leaf fossils.

2. Study from permanent slides: T.S. of stem of *Rhynia*, *Lepidodendron*, *Calamites*, *Lyginopteris*, *Cordaites*.

3. Study of pollen types (colpate, porate and colporate) from permanent slides.

Slides may be prepared from specimens: colpate (*Leonurus sibiricus*/ *Brassica* sp.), porate (*Hibiscus rosa-sinensis*), colporate (*Cassia sophera*/ *C. tora*).

4. Detection of honey type (uni/ bi/ multifloral) based on microscopic analysis.

5. Visit to a palaeobotanical/palynological laboratory/ institute/ museum.

Textbook References:

1. Stewart, W.N. & Rothwell, G.W. Palaeobotany & Evolution of Plants, Latest Ed., Cambridge University Press

2. Agashe, S.N. Palaeobotany, Latest Ed., Oxford & IBH

3. Thomas, B.A. & Spicer, R.A. The Evolution & Palaeobotany of Land Plants, Latest Ed., Croomhelm

4. Nair, P.K. Pollen Morphology of Angiosperms, Latest Ed., Scholar Publications

5. Shivanne, K.H. 2003. Pollen Biology & Biotechnology, Oxford & IBH

6. Bhattacharya, K., Majumdar, M.R. & Gupta Bhattacharya, S. 2006. A Text Book of Palynology, New Central Book Agency.

7. Taylor, T.N. and Taylor, E.L. 1993. The biology and evolution of fossil plants, First Ed. Englewood Cliffs: Prentice Hall.

PHARMACOGNOSY & ETHNOBOTANY

BOT-H-CC8-4-T

(Total Marks 75, Credits 3, Lectures 45 hours)

Unit I

Medicinal botany: History, scope and importance of medicinal plant in herbal drug industry, a brief idea about traditional systems of medicine- ayurveda, siddha and unani, Polyherbal formulations.

6 lectures

Pharmacognosy- General account : Pharmacognosy and its introduction and importance in modern medicine, Crude drugs, Classification of plant drugs- chemical and pharmacological action, Drug evaluation– organoleptic, microscopic, chemical, physical and biological, Major pharmacological groups of plant drugs and their uses, Conservation of endangered and endemic medicinal plants.

8 lectures

Unit II

Secondary metabolites: Secondary metabolites and their differences with primary metabolites, Interrelationship of basic metabolic pathways (Shikimate, Mevalonate, Acetate & MEP) with secondary metabolite biosynthesis (outlines only), Major types and classification–terpenoids, phenolics, flavonoids, alkaloids and their pharmacological importance. **8 lectures**

Pharmacologically active constituents:

Source plants (one example) parts used and uses of- Steroids (Solasodin, Diosgenin, Digitoxin), Tannin (Catechin), Resins (Gingerol, Curcuminoids), Alkaloids (Quinine, Atropine. Pilocarpine, Strychnine, Reserpine, Vinblastine, Taxol, Pyrolizidine), Phenols (Sennoside and Capsaicin). **8 Lectures**

Unit III

Ethnobotany and folk medicine: Definition, methods of study, application, Indian scenario, national interacts, folk medicines in ethnobotany, ethnomedicine, ethnoecology, ethnic communities of India, sacred groves, application of natural products to certain diseases- jaundice, cardiac, infertility, diabetics, blood pressure and skin diseases, challenges in application of ethno medicines with reference to modern medicines. **7 lectures**

Neutraceuticals: General introduction, classification, inorganic mineral supplements, multivitamins, digestive enzymes, probiotics, prebiotics, dietary fibres, health drinks, antioxidants, polyunsaturated fatty acids, herbs as functional foods- future of pharmacognosy. **8 lectures**

PHARMACOGNOSY & ETHNOBOTANY

BOT-H-CC8-4-P

Total Marks 25; Credit 1, Class 30 hours

1. **Workout (Items 1-4) 12 marks**
2. **Identification of common medicinal plants from fresh specimen/ herbarium 5 marks**
3. **Classroom performance (Laboratory Records) 3 marks**
4. **Viva-voce 5 marks**

PHARMACOGNOSY/ MEDICINAL PLANTS

1. Chemical tests for (a) Tannin (*Camellia sinensis* / *Terminalia chebula*), (b) Alkaloid (*Catharanthus roseus*).

2. Powder microscopy – *Zingiber* and *Holarrhena*.

3. Histochemical tests of (a) Curcumin (*Curcuma longa*), (b) Starch in non-lignified vessel (*Zingiber*),

(c) Alkaloid (stem of *Catharanthus* and bark of *Holarrhena*).

4. Determination of palisade ratio and vein-islet number of Vasak leaves.

5. Identification from fresh specimen/ herbarium of some commonly used medicinal plants:

a. *Azadirachta indica* (Neem), b. *Justicia adhatoda* (Vasak), c. *Andrographis paniculata* (Kalmegh), d. *Saraca asoca* (Ashoka), e. *Holarrhena pubescens* (Kurchi), f. *Centella asiatica* (Thankuni), g. *Zingiber officinale* (Ginger), h. *Catharanthus roseus* (Nayantara), i. *Phyllanthus emblica* (Amla), j. *Terminalia chebula* (Haritaki),k. *Terminalia arjuna* (Arjun), l. *Piper longum* (Long pepper), m. *Curcuma longa* (Turmeric), n. *Bacopa monnieri* (Brahmi)

Textbook References:

1. Trease & Evans. Pharmacognosy, Saunders.

2. Trivedi P.C. 2006. Medicinal Plants: Ethnobotanical approach, Agrobios India

3. S.K. Jain, 1995. Manual of Ethnobotany, Scientific Publishers, Jodhpur.

Semester 5

DSC/Core

MYCOLOGY

BOT-H-CC9-5-T

Total marks 75; Credits 3, Class 45 hours

1. Hyphal forms; Thallus organization; fungal cell structure; Reproduction (Asexual and sexual) and degeneration of sex; Fungal spore forms and mode of liberation; Life cycle patterns; Affinities with plants and animals; classification (Hawksworth et al 1995, Hibbett et al. 2007); Fungal DNA Barcoding – a tool for molecular identification. 7 lectures
2. Chytridiomycota: General characteristics; Zygomycota: General characteristics; Ascomycota: General characteristics, types of ascocarps, sexual reproduction and development of ascus and ascospores; Basidiomycota: General characteristics, phenomenon of dikaryotization, development of basidiocarps, basidia and basidiospores; Allied Fungi: occurrence, General characteristics, types of plasmodia; Oomycota: General characteristics; Life cycle of *Synchytrium*, *Rhizopus*, *Saccharomyces*, *Ascobolus*, *Agaricus*, and *Phytophthora*. 14 lectures
3. Physiology of spore dormancy, activation, and germination; Fungal nutrition; Nutrition uptake; Growth of Fungi, Environmental factors influencing growth; Chitin, Trehalose and glycogen synthesis in fungi; Fungal secondary metabolites; An outline of polyketides biosynthesis.
   8 lectures
4. Mitotic and meiotic cell division in fungi; Haploid mapping (*Neurospora*), sexual compatibility; Sex hormones in fungi; Parasexual cycle; Extrachromosomal inheritance in fungi; Fungal protoplast, Transformation and gene manipulation in filamentous fungi.
   8 lectures
5. Food and beverages from fungi (fungi to enhance food value- Cheese, Soy sauce; wine, beer and spirit, Fungi as functional food and nutraceuticals); Mycoprotein (*Fusarium venenatum*); Industrial Production of alcohol, citric acid and antibiotics; Mycoses (Types, diagnosis and treatments); Mycoremediation.
   8 lectures

MYCOLOGY

BOT-H-CC9-5-P

Total marks 25; Credit 1, Class 30 hours

1. Work out	**10 marks**
2. Identification with reasons	**5 marks**
3. Practical notebook	**3 marks**
4. Field notebook	**2 marks**
5. Viva-voce	**5 marks**

1. Introduction to basic Mycological Techniques and Laboratory Safety; Methods of sterilization, media preparation and culturing.
2. Isolation of fungi from soil/air by the culture plate technique.
3. Work out the following fungi with reproductive structures (including microscopic measurement of Reproductive structures): *Rhizopus*, *Ascobolus*, *Agaricus*, *Aspergillus*, *Alternaria/ Fusarium*. Permanent slide preparation.
4. Hyphal types from poroid fungi.
5. Ethanol production.
6. Identification of specimens from the field trip.

Suggested Readings

1. Webster, J. and Weber, R. (2007) Introduction to Fungi. 3rd edition. Cambridge University Press, Cambridge.
2. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (2007) Introductory Mycology, 4th edition, John Wiley & Sons (Asia) Singapore.
3. Chelin Rani Gnanam (2021) Introduction to Mycology, Mjp Publisher
4. Jim Deacon (2005) Fungal Biology, Wiley-Blackwell
5. Punshi S. K. Fungal infections with Color Atlas, 1st Edition, Jaypee Brothers Medical Publishers Pvt. Ltd
6. Duane R. Hospenthal, Michael G. Rinaldi, Thomas J. Walsh (2023) Diagnosis and Treatment of Fungal Infections, Springer Nature
7. Aneja, K.R. and Mehrotra R.S. (2015) An Introduction to Mycology, New Age International Private Limited
8. Gopinath Hait (2017) A Textbook of Mycology, New Central Book Agency
9. Thomas Carrey (2022) Mycology: A Comprehensive Approach, States Academic Press
10. Dube, H.C. (2013). A Text Book of Fungi, 4th Edition. Scientific Publishers (India)
11. Moore, C.J.– Landecker (1996) Fundamentals of the Fungi, 4th Edition (1996), Prentice Hall.
12. Sethi, I.K. and Walia, S.K. (2011). Textbook of Fungi and Their Allies, Macmillan Publishers India Ltd.
13. Zhiqiang An (2004) Handbook of Industrial Mycology, Taylor & Francis Inc
14. Kale, V and Bhusari, K (2021). Applied Microbiology. Himalaya Publishing House, Mumbai.

MICROBIOLOGY

BOT-H-CC10-5-T

Total marks 75; Credits 3, Class 45 hours

1. Introduction to Microbiology: Introduction to microbial world. Contributions of Anton von Leeuwenhoek, Louis Pasteur, Robert Koch, Joseph Lister, Alexander Fleming, Martinus William Beijerinck, Sergei N. Winogradsky, Selman A.Waksman, Paul Ehrlich, Elie Metchnikoff, Edward Jenner;

Systems of bacterial classification, Numerical taxonomy, Identifying characters for classification, General properties and principles of classification of microorganisms, Systematics of bacteria, Nutritional types [Definition and examples]. Isolation of pure cultures, Types of culture media, maintenance and preservation of bacterial cultures. Distinguishing features of Archaea and Bacteria. Characteristics of some major groups: Proteobacteria (Enterobacteria), Firmicutes, Mollicutes, Actinobacteria, Spirochaetes, Chlamydiae, mycoplasma. **…….8 lectures**

2. General Microbiology: Bacterial growth curve and generation time, Methods of Measurement of bacterial growth, batch, fed batch, continuous and synchronous growth. Physico-chemical factors influencing bacterial growth. Cell wall – chemical structure and differences between Gram +ve & Gram – ve bacteria, Endospore - formation, structure and function, Flagella (ultrastructure) & Pilli,

Genetic Recombination (a) Transformation – with special emphasis on Natural and Induced competence and DNA uptake, (b) Conjugation─ F- factor, F^+ X F^-, Hfr X F^-, concept of F', chromosome mobilization, (c) Transduction– Generalised and specialized. Plasmids, types and function, their application in modern biology. CRISPR-CAS.

…….10 lectures

3. Economic Importance: Bio-ethanol and bio-diesel production: commercial production from lignocellulosic waste, Biogas production: Methane and hydrogen production using microbial culture. Microorganisms in bioremediation: Degradation of xenobiotics, mineral recovery, removal of heavy metals from aqueous effluents.

Microbes in phyllosphere, water- fresh and marine and air. Microbial interactions- symbiosis, synergism, commensalism, parasitism, amensalism, antagonism and predation. A general account of Endophytes and their interaction with host

Microbial spoilage of foods– meat, milk, fruits, vegetables and their products; Food poisoning and Food borne pathogenic bacteria- Salmonellosis, Botulism, Cholera, *E.coli* –poisoning.

10 lectures

4. Medical Microbiology: Control of Microbes: Physical agents- Sunlight, Temperature, steam at atmospheric pressure and steam under pressure, irradiation, filtration.

Chemical Agents- Alcohol, aldehyde, Dyes, Halogens, Phenols, Ethylene oxide.

Principles of chemotherapy, general mode of action of various chemotherapeutic agents: Sulfa drugs, antibiotics- classification and mode of action.

Normal microbial flora of the human body. **…….. 7 lectures**

5. Virus: Viruses: Discovery, physiochemical and biological characteristics; One step growth curve.Baltimore Classification, General structure with special reference to viroids and prions;

   Replication (general account); Lytic cycle (T4 phage) and Lysogenic cycle (Lambda phage), Significance of lysogeny,

   Plant virus- types, Transmission and translocation of Plant virus, *Symptoms, Causal organism, Disease cycle and Control measures of TMV, Cucumber mosaic virus (CMV), Tomato spotted wilt virus (TSWV),, Cauliflower Mosaic Virus (CaMV)*

   Economic importance of viruses with reference to vaccine production, role in research, medicine and diagnostics. **…….10 lectures**

MICROBIOLOGY
BOT-H-CC10-5-P
Total marks 25; Credit 1, Class 30 hours

1. Work out	**10 marks**
2. Identification with reasons	**5 marks**
3. Classroom performance (Practical notebook)	**5 marks**
4. 5. Viva-voce	**5 marks**

1. Principles and application of Laboratory instruments- laminar air flow, incubator, autoclave, and incubator shaker.
2. Preparation of Nutrient agar slant, stab, agar plate and nutrient broth and inoculation of bacteria
3. Pure culture techniques: streaking and serial dilution of bacteria from soil, air / water.
4. Bacterial staining- single and mixture of bacteria: Grams staining and negative staining. Study of morphology, Gram Identification and comparison of the results.
5. Pure culture techniques: streaking and serial dilution of bacteria from soil, air / water.
6. Growth curve of bacteria by colorimeter.
7. Antibiotic sensitivity assay disc diffusion method.
8. Microbiological analysis of milk by MBRT assay
9. Biochemical characterization: Starch hydrolysis, Casein hydrolysis.

Suggested Readings

1. General Microbiology by R.Y. Stanier, JL Ingrahm, ML Wheelis and PR Painter.
2. Microbiology: Fundamentals and Applications by RM Atlas.
3. General Microbiology by HG Schlegel
4. Introduction to Modern Virology by NJ Dimmock, A J Easton and K N Leppard
5. Basic Virology by EK Wagner, MJ Hewlett, DC Bloom and D Camerini.
6. Microbiology by Prescott L, Harley J, Klein D.
7. Microbiology by pelczar chan and krieg

BIOCHEMISTRY
BOT-H-CC11-5-T
Total marks 75; Credits 3, Class 45 hours

1. **Biochemical Foundations:** Covalent and non-covalent bonds; hydrogen bond; Van der Waals forces; 1.2. Structure and properties of water; pH and buffer (inorganic and organic), Handerson-Hasselbalch equation; Isoelectric point. …….6 lectures

2. **Molecules of life:** Nucleic Acids – structure of nucleosides and nucleotides; oligo- and polynucleotides , A, B & Z form of DNA, RNA- different forms; nucleotide derivatives (ATP, NADP), Hoogstein base pairing of nucleic acids, Concept of sugar puckering and base stacking; torsion angle and supercoiling of nucleic acid, Proteins – structure and classification of amino acids; primary, secondary, tertiary and quaternary structure of proteins; Protein folding: Leventhal paradox; principles of protein purification, Carbohydrates -, Structure of Carbohydrate: stereochemistry – Fischer projection, Haworth perspective, boat and chair conformation, enantiomers and epimers; inverted sugar, derivative sugar, Lipids - structure of simple lipid and compound lipid (phospholipids and glycolipids), major classes of storage and structural lipids; fatty acids- saturated and unsaturated; Essential fatty acids; Triacyl glycerols structure, functions and properties. …….20 lectures

3. **Enzymology:** Enzymes – classification and nomenclature (IUBMB); Co-factors and co-enzymes; isozymes, Enzyme activity and specificity, active site, activation energy, Reaction rate, Mechanism of enzyme action; enzyme inhibition; Enzyme kinetics (Michaelis- Menten equation and Lineweaver Burk plot), simple problems on enzyme kinetics. ……10 lectures

4. **Cell membrane:** Membrane chemistry, Membrane transport (uniport, symport, antiport), mechanism of ion uptake. ……5 lectures

5. **Signal transduction**: Basic concept of signal transduction, receptor-ligand interactions, calcium signalling, Cyclic AMP, G protein, MAP-kinase cascade.

…….5 lectures

6. **Bioenergenetic**s - Laws of thermodynamics, concept of free energy, endergonic and exergonic reactions, coupled reactions, redox reactions. ATP: structure, its role as energy currency molecule**.** Energy rich bonds- phosphoryl group transfer. 5 lectures

BIOCHEMISTRY
BOT-H-CC11-5-P
Total marks 25; Credit 1, Class 30 hours

1. Experiments: Quantitative (10) & Qualitative (5)	**15 marks**
2. Laboratory notebook	**5 marks**
3. Viva	**5 marks**

Qualitative:

1. Detection of organic acids: citric, tartaric, oxalic and malic acid from laboratory samples.
2. Detection of carbohydrate and protein from plant samples.
3. Detection of the nature of carbohydrate – glucose, fructose, sucrose and starch from laboratory samples.
4. Detection of Ca, Mg, Fe, S from plant ash sample.

Quantitative:

1. Preparation of solutions and buffers.
2. Estimation of amino-nitrogen by formol titration method (glycine) .
3. Estimation of glucose by Benedicts quantitative reagent.
4. Estimation of catalase activity in different plant samples..
5. Estimation of urease activity in plant samples.
6. Determination of Km value of Urease.
7. Colorimetric estimation of protein by Folin phenol reagent.

Suggested Readings

1.Taiz, L., & Zeiger, E. Plant Physiology (4th ed.), 2006, Sinauer Associates, Inc. Publishers.
2. Hopkins, W.G. & Hiiner, N.P. Introduction to Plant Physiology (3rd ed.) 2004, John Wiley & Sons.
3. Salisbury, F.B. & Ross, C.W. Plant Physiology (4th ed.), 19992, Wadsoworth Publishing Company.
4. Mukherjee, S. & Ghosh, A. Plant Physiology (2nd ed.), 2005, New Central Book Agency.
5. Hames, B.D. Bio-Chemistry (2nd ed.) Viva Books.
6. Sackheim, G. Chemistry for Biology Students (5th ed.) 1996, Benjamin/Cummings
7. Heldt, Hans-Walter. Plant Bio-Chemistry (3rd ed.), 2005. Elsevier Academic Press.
8. Chaudhuri, D., Kar, D.K., and Halder, S.A. Handbook of Plant Biosynthetic Pathways 2008, New Central BookAgencies.
9. Mehta, S.L., Lodha, M.L. & Bane, P.V. Recent Advances in Plant Biochemistry, 1989. I.C.A.R.
10. Conn, E.E. and Stumpf, R.R. Outlines of Bio-Chemistry, Latest Ed., Wiley Eastern.
11. Lehninger Principles of Biochemistry. Sixth Edition. 2013. David L. Nelson, Michael M. Cox. Freeman,Macmillan.
12. Berg, J.M., Tymoczko, J.L., & Stryer, L., Bio-Chemistry, Latest Ed., Freeman Publ.

CELL and MOLECULAR BIOLOGY

BOT-H-CC12-5-T

Total marks 75; Credits 3, Class 45 hours

Cell Biology

1. Origin and Evolution of Cells: Evolution of nucleic acid (from PNA to DNA), Concept of RNA world, Ribozymes, First cell, Origin of eukaryotic cell (endosymbiotic theory), Small RNA- riboswitch, RNA interference, siRNA, miRNA, snRNA, hnRNA- brief idea, Organellar DNA (cp- and mt- DNA)

…2 lectures

2. Techniques of Study: Microscopy (Simple, Compound, Electron-SEM and TEM), Spectrophotometry, Electrophoresis (Principle and applications of native polyacrylamide gel electrophoresis and SDS PAGE). Western blot, Southern blot and Northern blot. FISH and GISH.

…….6 lectures

3. Nucleus & Chromosome: Nuclear envelope, nuclear lamina and nuclear pore complex. Nucleolus-ultrastructure and ribosome biogenesis. Chromatin ultrastructure and DNA packaging in eukaryotic chromosomes (Nucleosome Model). Centromere: types, structure and function.

…….4 lectures

4. Cell cycle and its regulation: Basic introduction to cell cycle: Mitosis and cytokinesis; comparison between plant, animal and yeast cell cycle; chromosome and chromatids positions, structures during pro-meta-ana- telo phase in detail; Spindle pole body organization, duplication, maturation in yeast cell cycle; mitotic check points and role of MPF; proteins involved in cytokinesis- how actomyosin contractile ring forms, matures and constricts in yeast cytokinesis followed by septum formation and generation of two daughter cells.

Apoptosis, Autophagy and Necrosis: Definition and concept; apoptosis: extrinsic and intrinsic pathways Cancer: Development and causes of cancer, Types of cancer. Proto Oncogene, oncogenes-Ras, BCL-2, Tumour suppressor genes-p53, p21 and DNA Repair Gene. **.10 lectures**

Molecular Biology

1. DNA Replication, Transcription and Translation (Prokaryotes & Eukaryotes): Central Dogma concept, Semiconservative DNA replication – mechanism, enzymes involved in DNA replication- DNA polymerase, DNA gyrase, Helicase, Ligase, primase and other accessory proteins, Eukaryotic replication with special reference to replication licensing factor, assembly of new nucleosome, telomerase concept, Fidelity of DNA replication-prokaryote: nucleotide selection, proofreading, mismatch repair, Transcription: concept of prokaryotic and eukaryotic transcription. Steps of initiation, elongation and termination in prokaryotes, RNA editing, Guide RNA, Aminoacylation of tRNA, Translation: Difference between prokaryotic and eukaryotic translation. Prokaryotic translation steps- initiation, elongation and termination. Concept of genetic code- wobble hypothesis; Descipherence of codon. **…….8 lectures**

2. Gene Regulation: Operon: Concept of Lac-operon, Positive and negative control. **.2 lectures**

3. Recombinant DNA Technology: Recombinant DNA technology, Restriction endonuclease, types and roles, Vector (plasmid pBR 322), Marker gene and Reporter gene, Steps of cloning technique, PCR and its application, Genomic DNA and cDNA library, DNA fingerprinting and role of DNA Fingerprinting in Forensic Science.

…….5 lectures

CELL and MOLECULAR BIOLOGY

BOT-H-CC12-5-P

Total marks 25; Credits 1, Class 30 hours

1.	**Work out (Major +Minor)**	**10+5=15**
2.	**Laboratory Records**	**5**
3.	**Viva-voice**	**5**

1. Introduction to light compound microscope: Identify each part and their usage in the microscope; how to focus live cells (plant cells from onion peels/leaf-like Setrecia or spinach / E coli/ yeast) under the microscope and perform measurements; use of oil immersion lens; microscopic resolution and numerical apertures.
2. Counting cells per unit volume with the help of a haemocytometer (Yeast/pollen grains)
3. Accurate pipetting and weighing scale usage: practicing accurate pipetting by setting up different reaction volumes of solution A (water) and solution B (any solution like calcium chloride, magnesium chloride, etc) and then use the weighing scale to check their accuracy.
4. Isolation of plant genomic DNA by the C-TAB method and DNA estimation by UV/colorimetric.
5. Study of the nucleolus through hematoxylin/orcein staining and determination of nucleolar frequency.
6. Estimation of DNA content through DPA staining.
7. Estimation of RNA through the orcinol method.
8. Preparation of models/charts: rolling circle, theta replication, semi-discontinuous replication, prokaryotic RNA polymerase and eukaryotic RNA polymerase II, assembly of spliceosome machinery, splicing mechanism in group I and group II introns, ribozyme and alternative splicing.

Suggested Readings

1. Watson JD, Baker TA, Bell SP, Gann A, Levine M and Losick R (2008) Molecular Biology of the Gene, 6th edition, Cold Spring Harbour Laboratory Press, Pearson Publication.

2. Brown TA. Gene Cloning and DNA Analysis. Wiley.
3. David Freifelder. Molecular Biology.
4. Cooper, G.M. and Hausman, R.E. (2009). The Cell: A Molecular Approach. 5th Edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
5. Sharma, V. K. (1991). Techniques in microscopy and cell biology. Tata McGraw-Hill.
6. Nelson D. L. and Cox M.M. (2008) Lehninger Principles of Biochemistry, 5th Edition.
7. W.H. Freeman and Company.
8. Scott F Gilbert. Developmental Biology, 6th edition. Sunderland (MA): SinauerAssociates; 2000. ISBN-10: 0-87893-243-7
9. Cell and Molecular Biology: Concepts and Experiments. Gerald Karp.

Semester 6

PHYTOPATHOLOGY
BOT-H-CC13-6-Th
Total marks 75; Credits 3, Class 45 hours

1. The history and development of plant pathology; Disease concept; signs and symptoms; Etiology and causal complex; Primary and secondary inoculum; Infection; Pathogenicity and pathogenesis; Necrotroph and Biotroph; Koch's Postulates; Endemic, Epidemic, Pandemic and Sporadic disease; Disease triangle and pyramid; Disease cycle (monocyclic, polycyclic and polyetic); Plant disease epidemiology. 8 lectures

2. Pathogenesis- Inoculation; Attachment; Appressorium formation and maturation; Penetration; Role of chemical weapons in pathogenesis (enzymes, toxins and growth regulators); Genetics of plant disease and resistance- Genes and disease; Specialized mechanisms of variability in pathogens; Gene-for-Gene concept.

10 lectures

3. Plant defense- Preexisting and induced structural and biochemical defense; Recognition of the pathogen by the plant- Elicitors and Plant receptors; Rapid ion flash; Active oxygen species; Pathogenesis-related proteins; Defense through the production of secondary metabolites; Hypersensitive reactions; PTI and ETI.

9 lectures

4. Symptoms, Causal organism, Disease cycle and Control measures of:Late blight of Potato; Brown spot of rice; Black stem rust of wheat; Stem rot of jute; Citrus canker; Tobacco Mosaic Disease.

10 lectures

5. Control of plant diseases: Molecular diagnosis of plant diseases: Plant health legislation; Cultural, chemical and biological control of plant diseases; Integrated pest management; Biotechnology for plant disease control.

8 lectures

PHYTOPATHOLOGY
BOT-H-CC13-6-P
Total marks 25; Credit 1, Class 30 hours

1. Work out	**10 marks**
2. Identification with reasons	**5 marks**
3. Practical notebook	**3 marks**
4. Herbarium specimens of diseases	**2 marks**
5. Viva-voce	**5 marks**

1. Sterilization and incubation - principles and uses of instruments, Culture media and their preparation, Preparation of stabs, slants, and pouring of plates.
2. Isolation of the pathogen from diseased tissues, permanent slide preparation
3. Preparation of pure culture and subculturing.
4. Inoculation of tuber/stem/fruit.
5. Histopathology of Rust of *Justicia*, Loose smut of wheat/False smut of rice, Powdery mildew of cucurbits, White rust of *Amaranthus*. Slides of uredial, telial, pycnial and aecial stages of *Puccinia graminis*.
6. Study of symptoms from herbarium specimens - bacterial diseases: Citrus Canker; Viral diseases: Vein clearing; Fungal diseases: Early and Late blight of potato, Brown spot and blast of rice, Stem rot of jute, White rust of *Amaranthus*, Leaf Spot of *Basella*, Powdery mildew of Cucurbits.

Suggested Readings

1. Agrios, G.N. (1997). Plant Pathology, 4th edition, Academic Press, U.K.
2. Mehrotra, R.S. and Aggarwal A. (2017). Plant Pathology. McGraw Hill India.
3. Singh, R.S. (2017) Introduction To Principles Of Plant Pathology, Medtech Publishers.
4. Rangaswami, G. (1988) Diseases of crop Plants of India, 3rd edition, Prentice Hall, India.
5. Sethi, I.K. and Walia, S.K. (2011). Textbook of Fungi and Their Allies, Macmillan Publishers India Ltd.
6. Persley, GJ (1996). Biotechnologies and Integrated Pest Management. CAB International, U.K.
7. Sambamurty, AVSS (2006). A Text Book of Plant Pathology. IK International Publishing House Pvt. Ltd., New Delhi.
8. Balaji Aglave (2018) Handbook of Plant Disease Identification and Management, CRC Press
9. Tripathi, SK, Bhale, MS, Yadav, VK and Shrivastava, A (2022). Fundamentals of Plant Pathology. Scientific Publishers, India
10. M. Elangovan, Rashmi Nigam, Sankarganesh E, Geetika Srivastava (2024) Plant Diseases: Diagnosis, Management, and Control, AGPHBooks
11. Gupta, V. K. (2011) Integrated Disease Management And Plant Health, Scientific (Publication)
12. Meena A.K. (2022) Detection And Diagnosis Of Plant Diseases, Scientific Publishers
13. Prahlad Masurkar, Adesh Kumar, Vipul Kumar (2025) Applications of Biotechnology in Plant Pathology, CRC Press

PLANT PHYSIOLOGY
BOT-H-CC14-6-Th
Total marks—75, Credits-3, Class—45 hours

1. Plant-water relations:

Water Potential and its components, water absorption by roots, aquaporins, pathway of water movement, symplast, apoplast, transmembrane pathways, root pressure, guttation. Ascent of sap– cohesion-tension theory. Transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal movement. Role of carbon di-oxide, potassium ion, abscisic acid and blue light in stomatal movement.

6 lectures

2. Mineral nutrition: Essential and beneficial elements, macro and micronutrients, methods of study and use of nutrient solutions, criteria for essentiality, mineral deficiency symptoms, roles of essential elements, chelating agents. 5 lectures

3. Nutrient Uptake and Organic Translocation: Nutrient Uptake --Soil as a nutrient reservoir, transport of ions across cell membrane, passive absorption, electrochemical gradient, facilitated diffusion, active absorption, role of ATP, carrier systems, proton ATPase pump and ion flux, uniport, co-transport, symport, antiport. 5 lectures

Translocation in the phloem -- Experimental evidence in support of phloem as the site of sugar translocation. Pressure–Flow Model and its critical evaluation; Phloem loading and unloading; Source–sink relationship.

6 lectures

4. Plant Growth Regulators and Physiology of flowering: Plant growth regulators--Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene. Mode of action of IAA. Brassinosteroids ,Jasmonic acid and Polyamines as PGRs (brief idea).

10 lectures

Physiology of flowering --Photoperiodism, flowering stimulus, Phytochrome, cryptochrome and phototropins-chemical nature and role in photomorphogenesis. low energy responses (LER) and high irradiance responses (HIR), mode of action. Vernalisation – role of low temperature in flowering, Concept of biological clock and biorhythm. 8 lectures

5.Dormancy and Senescence: Dormancy- Types, Causes and Methods of breaking seed dormancy, Biochemistry of seed germination. Acid growth hypothesis and starch statolith concept of IAA, GA and ABA mediated hormonal regulation of dormancy and germination, Physiology of Senescence and Ageing.

5 lectures

PLANT PHYSIOLOGY
BOT-H-CC14-6-P
Practical (Full marks—25, Credit-1)

1. Plant Physiology experiment (1 major and 1 minor)	10 +5 =15
2. Classroom performance (Laboratory records)	5
3. Viva- voce	5

Major experiments:

1. Determination of loss of water per stoma per hour.

2. Relationship between transpiration and evaporation.

3. Measurement of osmotic pressure of storage tissue by weighing method.

4. Measurement of osmotic pressure of *Rhoeo* leaf by plasmolytic method.

5. Effect of temperature on absorption of water by storage tissue and determination of Q_{10}.

6. Rate of imbibition of water by starchy, proteinaceous and fatty seeds and effect of seed coat.

7. Determination of rate of transpiration by two surfaces of a leaf.

Minor experiments:

1.Determination of the temperature at which beet root cells lose their permeability.

2. Measurement of Relative water content of a leaf.

3. Determination of seed viability by tetrazolium test

4. Preparation of different concentration of Molar,Molal,Normal and Percent solutions from Stock solution.

5. Determination of stomatal frequency of a leaf.

6. Preparation of buffer (Acetate buffer and Phosphate buffer).

Suggested Books:

1.Taiz, L., & Zeiger, E. Plant Physiology (4th ed.), 2006, Sinauer Associates, Inc. Publishers.
2. Lincoln Taiz, Eduardo Zeiger, Ian M. Møller, and Angus Murphy.Plant Physiology and Development. (6^{th} ed.)Sinauer Associates.
3. Hopkins, W.G. & Hiiner, N.P. Introduction to Plant Physiology (3rd ed.) 2004, John Wiley & Sons.
4. Salisbury, F.B. & Ross, C.W. Plant Physiology (4th ed.), 19992, Wadsoworth Publishing Company.
5. Wilkins, M.B. Advances Plant Physiology. 1984, ELBS Longman.
6. Davies P.J. (ed.) Plant Physiology: Physiology, Bio-Chemistry & Molecular Biology, Academic Press.
7. Mukherjee, S. & Ghosh, A. Plant Physiology (2nd ed.), 2005, New Central Book Agency.
8. Raman, H. Transport Phenomenon in Plants, 1997. Narosa Publishing House.
9. Voet, D. and Voet, J.G., Bio-Chemistry (3rd ed.), 2005, John Wiley & Sons.
10. Lehninger Principles of Biochemistry. Sixth Edition. 2013. David L. Nelson, Michael M. Cox. Freeman, Macmillan.
11. Singhal, G.S. Concepts of Photobiology: Photosynthesis & Photomorphogenesis, 1999. Narosa Publishing House.
12. Buchanon, Gruissen and Jones. Plant Physiology & Biochemistry: Biochemistry and Molecular Biology of plants, 2000, I.K. International.

GENETICS
BOT-H-CC-15-6-Th
Total marks 75; Credits 3, Class 45 hours

1. Introduction: Mendelian genetics and its extension (Modification of Mendelian ratios)

.....2 lectures

2. Linkage, Crossing Over, and Gene Mapping: Sex Chromosomes and Chromosomal Aberrations. - Deletion, Duplication, Translocation, and Inversion, 2.2 Linkage and chromosome mapping in Eukaryotes- Complete and incomplete linkage (example), linked gene does not assort independently(example), linkage group, Crossing over, crossing over produces recombination (example), and Molecular mechanism of crossing over(Holliday model), Gene mapping with three-point test cross, detection of middle gene in three-point test cross, calculation of recombination frequencies, Co-efficient of coincidence and interference, mapping function, Problems on gene mapping. .....5 lectures

3. Eukaryotic transcription and translation: 3.1 Transcription factors and functions, Steps of transcription, Post-translational modifications (5' capping, polyadenylation, RNA splicing), Steps of translation including initiation, elongation, termination, post Post-translational modifications (phosphorylation, glycosylation, ubiquitination, acetylation, methylation), Importance of PTM in disease.

.....4 lectures

4. Mutation, DNA repair and transposition: Point Mutation-Transition, Transversion and Frame shift mutation, Molecular mechanisms (tautomerisation, alkylation, deamination, base analogue incorporation, dimerization), DNA repair, transposon (AC-DS system). .....2 lectures

5. Epistasis and Polygenic inheritance in plants: Incomplete inheritance and Codominance; Inter allelic-Complementary gene interaction (9:7) Ex: *Lathyrus odoratus*; Supplementary gene interaction (9:3:4) eg. Grain colour in Maize and (12:3:1); Epistasis - Dominant e.g.: Fruit colour in *Cucurbita pepo*, Polygenic inheritance in plants, QTL Mapping. .....3 lectures

6. Aneuploidy and Polyploidy: Types, examples, meiotic behaviour and importance of: Aneuploidy, Polyploidy, Speciation and evolution through polyploidy. .....2 lectures

7. **Autosomal and Sex-linked inheritance:** Autosomal dominant and recessive pattern of genetic inheritance with examples, X-linked inheritance (recessive and dominant with examples and phenotypes. Y-linked disorders. .....2 lectures

8. Genomics and Bioinformatics: Basic idea on Whole genome sequencing (WGS), Use of databases: GenBank, NCBI, Introduction to data analysis tools (e.g., BLAST), structure prediction of protein from amino acid sequence through alpha fold 3, Basic idea on molecular docking.

.....4 lectures

9. Population and evolutionary genetics: Gene pool, Allele frequency, Evolution, Natural selection, Genetic drift, Gene flow. .....2 lectures

10. Special topics: Genetic testing (carrier screening, prenatal screening), Gene therapy, forensics, GMOs and precision medicine. .....3 lectures

GENETICS
BOT-H-CC-15-6-P
Total marks 25; Credits 1, Class 30 hours

1. Workout	8 +4
2. Identification	3
3. Classroom performance (Laboratory Records and slides)	5
4.Viva-voice	5

Genetics

1. Introduction to chromosome preparation: Pre-treatment, Fixation, Staining, Squash and Smear preparation, Preparation of permanent slides.

2. Determination of mitotic index and frequency of different mitotic stages in pre-fixed root tips of *Allium cepa*.

3. Study of mitotic chromosome: Metaphase chromosome preparation, free hand drawing under high power objective, drawing with drawing prism under oil immersion lens, determination of 2n number, and comment on the chromosome morphology of the following specimens from root tips: *Allium cepa*, *Aloe vera*, *Lens esculenta*.

4. Study of chromosomal aberrations developed due to exposure to any one pollutants/ pesticides, etc.

5. Study of meiotic chromosomes: Smear preparation of meiotic cells, identification of different stages and free-hand drawing of the following specimens from flower buds: *Allium cepa* and *Setcreasea* sp.

6. Identification from permanent slides: Meiosis – (i) normal stages (ii) abnormal stages – laggard, anaphase bridge, ring chromosome (*Rhoeo discolor*); Mitosis – (i) normal stages, (ii) abnormal stages earlyseparation, late separation, multipolarity, sticky bridge, laggard, fragmentation, (ii) pollen mitosis.

7. Bioinformatics:

7.1 Gene sequence search from gene bank, primer design through benchling or snapgene and virtual gel run on a computer. Search for homologous gene lists using NCBI BLAST, 7.2. Structural prediction of protein by AlphaFold3 free online website.

Textbook

1. Pierce, Benjamin A. Genetics (2nd ed.), 2005, W.H. Freeman & Company.
2. Atherly, A.G., Girton, J.R. & McDonald, J.F. Science of Genetics, 1999, Saunders College Publications.
3. Hartwell, L.H., Hood, L., Goldberg, M.L., Reynolds, A.E., Silver, L.M. & Veres, R.C. Genetics (2nd ed.), 2004, McGraw-Hill.
4. Tamarin, Robert H. Principles of Genetics (7th ed., 2002, Tata McGraw-Hill.
5. Elrod, S.K. & Stanfield, W. Schuam's Outlines Genetics (4th ed.), 2002, Tata McGraw-Hill.
6. Hartl, D.L. & Jones, E.W. Genetics, 2005, Jones & Bartlett Publishers.
7. Lewin, B. Genes VIII, 2004, Pearson Educational International.
8. Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. &Losick, R. Molecular Biology of the Gene (5th ed.) 2004. Pearson Education Inc.
9. Griffiths, A.I.F., Miller, J.H., Suzuki, D.T., Lewentin, C.R. & Gilbert, M.W. An Introduction to Genetic Analysis, 2005 (8th ed.), W.H. Freeman & Company.
10. Brown, T.A. Genomes 3, 2007, Garland Science Publishing.

Semester 7

PLANT GEOGRAPHY, ECOLOGY AND EVOLUTION
BOT-H-CC16-7-Th
Credit 3, marks 75 , lectures 45

Unit I-PLANT GEOGRAPHY (25 marks)

Phytogeographical regions: Phytogeographical regions of India (Chatterjee 1960); Dominant flora of Eastern Himalaya, Western Himalaya and Sunderban. ….8 lectures

Endemism:

Endemic types and Factors; Age & Area hypothesis and Epibiotic theory; Endemism in Indian flora. Concept and Mechanism of Plant migration …….6 lectures

Unit II-ECOLOGY (25 marks)

Preliminary idea on:

Habitat and Niche, Ecotone and edge–effect, Microclimate, Ecads, ecotype and ecoclines, Carrying capacity. …….4 lectures

Community ecology:

Community- Characteristics and diversity, Ecological succession –Primary and secondary, Seral stages (with reference to Hydrosere), autogenic and allogenic succession, Concept of climax. ...….6 lectures

Plant indicators (metallophytes); Phytoremediation. …….4 lectures

Conservation of Biodiversity:

Level of Biodiversity: genetic, species & ecosystem diversity, Biodiversity hot spots- criteria, Indian hotspots, *In- situ* and *ex-situ* conservation, Seed-banks, Cryopreservation. ..16 lectures

Unit III- EVOLUTION (25 marks)

Introduction, Theories of evolution: Natural selection, Group selection, Neutral theory of molecular evolution, Phyletic gradualism, Punctuated equilibrium and Stasis ….6 lectures

Brief idea on: Stabilizing, directional, disruptive and sexual selection; Speciation: Sympatric and allopatric speciation; Coevolution, Adaptive radiation, Reproductive isolation ..4 lectures

Simplified phylogeny of bacteria, algae, fungi, bryophyte, pteridophyte and gymnosperm, Concept of Phylogenetic tree. …….6 lectures

PLANT GEOGRAPHY, ECOLOGY AND EVOLUTION
BOT-H-CC16-7-P
CREDIT 1, MARKS 25, LECTURES 15

1. **Experiments:** **12 marks**
2. **Lab notebook:** **4 marks**
3. **Field report:** **4 marks**
4. **Viva:** **5 marks**

PLANT GEOGRAPHY

1. Study of local flora and submission of field report highlighting phytogeographical characteristics of the region.

ECOLOGY

1. Study of community structure by quadrat method and determination of (i) Minimal size of the quadrat, (ii) Estimation of frequency, density and abundance of components (to be done during excursion/field visit).

2. Comparative anatomical studies of leaves from polluted and less polluted areas.

3. Measurement of dissolved O_2 by azide modification of Winkler's method.

4. Comparison of free CO_2 from different water sources.

Suggested Books:

1. Chapman and Riss. Ecology: Principles and Applications, Latest Ed., Cambridge University Press
2. Shukla, R.S. & Chandel, P.S. Plant Ecology, Latest Ed., S. Chandel and Co.
3. Kumar, H.D. Modern Concept of Ecology, Latest Ed. Vikas Publishing House
4. Begon, M., Herper, J.L. and Townsend, C.R. Ecology- Individuals, Populations and Communities (3rd ed.), Oxford Blackwell Science
5. Verma, P.S. & Agarwal, U.K. Concept of Ecology, Latest Ed., S. Chand & Company
6. Odum, F.P. Fundamentals of Ecology, Latest Ed., Saunders
7. Mani, M.S. Bio-Geography of India, Latest Ed., Springer-Verlag.
8. Mackenzie et al. Ecology, Latest Ed., Viva Books.
9. Kimar, U. & Asija, M.J. Bio-diversity: Principles & Conservation, 2005, Student Edition, Agrobios (India)
10. Mitra, D., Guha, J.K., Chowdhury, S.K. Studies in Botany, Vol. II (7th ed.) Moulik Library.
11. Primack, R.B. Essentials of Conservation Biology, 1993, Sinauer Associates.
12. Lo, C.P. & Yeung, A.K.W. Concepts and Techniques of Geographic Information Systems, 2002, Printice-Hall of India.
13. Cain, Bowman, Hacker. Ecology. 2014. 3rd Ed. Sinauer Associates
14. Futuyma., D. Evolution. 2015. (3rd Ed.) Sinauer Associates
15. Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Jane B. Reece. Campbell Biology. 2017. 11th Ed. Pearson

BIOSTATICS
BOT-H-CC17-7-Th
Credit 3, marks 75, lectures 45

Unit I

Introduction to Biostatistics: Brief idea of different statistical methods, uses and limitations of Biostatistics. ……..2 lectures

Collection of Data: Methods : Experimental and Surveying, Types of Data, Different types of sampling methods: Simple random sampling, Complex random sampling, Types of variables

……6 lectures

Methods of presentation of Data: Classification of Data, Frequency Distribution, Tabular presentation, Graphical representation (Frequency Polygon, Bar diagram, Histogram, Pie Diagram)

…..8 lectures

Unit II

Measures of Central tendency (Mean Median, Mode, quartile and percentile**),** Measures of Dispersion (Mean deviation**,** Standard Deviation And Standard Error**)** ….4 lectures

Types of distribution of Data : Normal Distribution, Binomial distribution, Poisson distribution, Skewness and Kurtosis ….2 lectures

Probability : Addition and Multiplicative rules of Probability with problems ...2 lectures

Correlation and Regression : types of Correlation , Coefficient of Correlation, Types of Regression and computation for Regression line. ……..6 lectures

Unit III

Testing of Hypothesis : Test of Significance of Mean : Student's 't' test: Paired and unpaired ; Chi-square Test: Test of Goodness of Fit and Contingency Chi-square test; Z -test (for mean deviation), F-test (test for variance).

Analysis of Variance for randomized block design …….15 lectures

BIOSTATICS
BOT-H-CC17-7-P
CREDIT 1, MARKS 25, LECTURES 15

1. Workout of problems 15 marks
2. Laboratory Notebook 5 marks
3. Viva voce 5 marks

1. Collection of primary data (leaf length of simple leaf, seedling length) Methods of presentation of Data : Tabular presentation of data , Frequency Distribution table preparation, Graphical representation of data (Frequency Polygon, Bar diagram, Histogram, Pie Diagram)
2. Measures of Central tendency and Measures of Dispersion
3. Test of Significance of mean : Student's 't' test: Paired and unpaired
4. Chi-square Test: Test of Goodness of Fit using Mendelian and Non Mendelian ratios (9:7, 13:3, 15:1)
5. Z- test (for mean deviation), and F-test (test for variance)
6. Determination of Coefficient of Correlation
7. Computer application in Biostatistics :Use of Excel / Graph Pad / SPSS

Books

1. Rohtagi V.K. and. Saleh A. K. M. E (2015): An Introduction to Probability Theory and Mathematical Statistics, 3rd Edition, Wiley.
2. Miller I. and Miller M. (1999): Mathematical Statistics, 6th Edition, Oxford & IBH Pub.
3. Ross S. M. (2014): Introduction to Probability Models, 11th Edition, Academic Press.
4. Goon A.M., Gupta M. K., Dasgupta B (2008): Fundamentals of Statistics, Published by Prentice Hall, 2nd edition.
5. Gupta S.C.& Kapoor V.K, (2000): Fundamentals of & Mathematical Statistics, Sultan Chand Sons 10th edition.
6. Croxton F.E., Cowden D.J. & Kelin S, (1967): Applied General Statistics, Prentice Hall.
7. Hogg and Craig, Introduction to Mathematical Statistics, (2013): Prentice Hall, 7th edition.
8. Steel and J H Torrie, Principles and procedures of statistics, (2007): McGraw Hill, 2nd edition.
9. Zar, J.H. Biostatistical Analysis (3rd ed.), 1996, Prentice Hall.
10. Barley, N.T.J. Statistical Methods in Biology, Latest Ed., Cambridge University Press
11. Pranab Kumar Banerjee, Introduction to Biostatistics (Latest Ed.) S.Chand &Company
12. Satguru Prasad, Elements of Biostatistics (Latest Ed.) Rastogi Publication
13. Misra And Misra , Introduction to Practical Biostatistics, Naya Prakash

PLANT BIOTECHNOLOGY
BOT-H-CC18-7-Th
Credit 3, Marks 75, Lectures 45

Unit I

Introduction to Plant Biotechnology: Concept of Biotechnology, Strategies of Biotechnology from ancient to recent (fermentation, natural selection, elicitation, tissue culture, genetic and molecular approach), Application to mankind: Insect, virus, draught and salt resistant plants. Plants with better nutritional quality, male sterile line, delayed senescence, pigmentation, edible vaccine, Environ mental remediation. ……8 lectures

Tools and Techniques of Gene Manipulation (Recombinant DNA Techniques: Basic Strategy of Gene cloning: Restriction endonuclease and other DNA modifying enzymes, Types of Vectors, Plant expression vectors with desirable promoters, marker and reporter genes for direct and indirect transfer, Genes for useful traits: Insect, virus, herbicide and resistance gene, Salinity and Drought tolerance gene, genes for improved nutritional quality, Site directed mutagenesis and Transposon mediated gene tagging. …..8 lectures

Unit II

Gene transfer techniques used for Plants and Testing for transgenic expression: Indirect gene transfer through Agrobacterium and Plant Virus, Direct gene Transfer through Physical and Chemical means, Marker free transgenic plants, use of gene silencing and genome editing for transgenic development, Transplastomic technology used in transgenic plant development. Integration and expression of Transgene, Screening and selection of transgenic plants using different techniques, Release of GM crops in field through tissue culture, Detection, quantification and harvesting of transgenic products from plant tissues or suspension culture. …..14 lectures

Unit III

Present status of GM crops and their acceptance in society: Different organizations and Laboratories engaged in transgenic development, GM crops their acceptance and limitations, Govt. regulations for different GM crops, Legal Issues, Biosafety and Ethical Issues. IPR and Patent for GM crops.

…..5 lectures

Other Biotechnological Tools used in Modern Biotechnology: Product enhancement using non-r-DNA tools: Elicitation for different compounds, Nanoparticle mediated techniques, Antisence technology for quality improvement (longer life of fruit and flower colour,) Single Cell Bioreactor, Metabolic Engineering for different plant products (flavoring agent, coloring agent, biopolymer), Plant Molecular Farming (Pharmaceuticals, Enzymes and carbohydrates),

Downstream processing of Plant Products, High–Throughput approach, System and Synthetic Biology, Smart Plant Engineering (Brief Idea). …10 lectures

PLANT BIOTECHNOLOGY
BOT-H-CC18-7-P
Credit 1, Marks 25, Lectures 15

1. Workout / demonstration	**15 marks**
2. Laboratory records and Poster	**5 marks**
3. Viva-voce	**5 marks**

1. Study of plant growth regulators (2,4-D /NAA and KN/BAP) on any explant (Root/Stem/hypocotyl/leaf).
2. Establishment of callus culture and suspension culture using carrot tissue.
3. Demonstration of *Agrobacterium* mediated transformation method using leaf or stem explants.
4. Isolation of Protoplast through enzymatic method.
5. Plasmid isolation from *E. coli* and DNA Gel electrophoresis
6. Isolation of total protein from leaf and SDS-PAGE
7. Extraction of plant secondary metabolites (quercetin from Onion dried peels and caffeine from Tea leaves) and detection of them by TLC method.
8. Preparation of poster on any aspect of biotechnology from the theory syllabus (Concept/Hypothesis, Methodology, Applications with specific examples, challenges).

Suggested books:

1. Adrian Slater, Nigel Scott and Mark Fowler, Plant Biotechnology (2nd Ed.), Oxford Publishers
2. H. S. Chawla, Plant Biotechnology, Oxford & IBH Publication
3. B.D. Singh, Plant Biotechnology, Med Tech Science Press
4. R.C.Dubey, A text Book of Biotechnology, S. Chand and Co.Ltd.
5. R.C.Dubey, Advanced Biotechnology, S. Chand and Co.Ltd.
6. C. Neal Stewart JR., Plant Biotechnology , Wiley India Pvt. Ltd.
7. Nigel Halford, Plant Biotechnology, John Wiley (Indian Edition)
8. U. Styanarayana and U. Chakrapani, Biotechnology, Books and Allied Ltd.
9. S. Mahesh, Plant Molecolar Biotechnology, New Age International Publishers

PLANT METABOLISM
BOT-H-CC19-7-Th
Total marks—75, Credits-3, Class—45 hours

Unit I

Concept of metabolism: Introduction, Anabolic and catabolic pathways, regulation of metabolism, role of regulatory enzymes (allosteric, covalent modulation and isozymes). …….**5 lectures**

Photosynthesis: Carbon assimilation: Photosynthetic pigments, action and absorption spectrum, role of photosynthetic pigments (chlorophylls and accessory pigments), antenna molecules and reaction centres, Components of photosystems photochemical reactions, Cyclic and noncyclic electron transport, water splitting mechanism, Q cycle, C_3, C_4(three variants of the pathway) and CAM pathways--- Biochemical reactions, stoichiometry , regulations and significance . Photorespiration – mechanism, regulation and significance. **10 lectures**

Unit II

Respiration: EMP pathway—biochemical reactions, regulation and its anabolic role, Conversion of Pyruvic acid to Acetyl CoA, TCA-cycle--biochemical reactions, regulation and its amphibolic role, Oxidative pentose phosphate pathway and its significance, Mitochondrial electron transport system, inhibitors and uncouplers, Oxidation of cytosolic $NADH^+H^+$,Cyanide resistant respiration, Stoichiometry of glucose oxidation (aerobic). .**10 lectures**

Nitrogen Metabolism: Biological nitrogen fixation (examples of legumes and non-legumes); genetic interactions between legumes and Rhizobia for nodule formation, nitrogenase enzyme- structure and biochemistry of nitrogen fixation, Assimilation of nitrate by plants, General principle of amino acid biosynthesis (including GS and GOGAT enzyme system). ….6 lectures

Unit III

Lipid metabolism: Synthesis and breakdown of triglycerides, ß-oxidation, glyoxalate cycle, gluconeogenesis and its role in mobilization of the lipids during seed germinations, α- oxidation and omega oxidation. .**7 lectures**

Oxidative metabolism:

Brief idea of ROS and antioxidative defence strategies. Mechanism of ATP synthesis, substrate level phosphorylation, oxidative and photophosphorylation chemiosmotic mechanism, ATP synthase complex. .**7 lectures**

PLANT METABOLISM
BOT-H-CC19-7-P
Credits 1

1. Experiments	**15 marks**
2. Laboratory Records	**5 marks**
3. Viva	**5 marks**

1. Separation of photosynthetic pigments by paper chromatography and measurement of R_f values.
2. Estimation of total chlorophyll content from different chronologically aged leaves (young, mature and senescence) by Arnon method.
3. Effect of HCO_3 concentration on oxygen evolution during photosynthesis in an aquatic plant and to find out the optimum and toxic concentration (either by volume measurement or bubble counting).
4. Compare the rate of respiration in different parts of a plant.
5. Measurement of oxygen uptake by respiring tissue (per g/hr.)
6. Determination of the RQ of different types of germinating seeds (starchy, proteinaceous, oil seed) .
7. Isolation of chloroplast and assay of Hill activity.
8. To study the activity of lipases in germinating oilseeds.

REFERENCES:

1. Taiz, L., & Zeiger, E. Plant Physiology (4th ed.), 2006, Sinauer Associates, Inc. Publishers.
2. Hopkins, W.G. & Hiiner, N.P. Introduction to Plant Physiology (3rd ed.) 2004, John Wiley & Sons.
3. Voet, D. and Voet, J.G., Bio-Chemistry (3rd ed.), 2005, John Wiley & Sons.
4 Lehninger Principles of Biochemistry. Sixth Edition. 2013. David L. Nelson, Michael M. Cox. Freeman,Macmillan.
5. Buchanon, Gruissen and Jones. Plant Physiology & Biochemistry: Biochemistry and Molecular Biology of plants, 2000, I.K. International.

NATURAL RESOURCE MANAGEMENT
BOT-H-CC20-7-Th
Credit 3, marks 75, 45 lectures

Unit I

Introduction to Natural Resources :

Concept and Classification of natural resources, Factors influencing resource availability, distribution and uses, interrelationship among different types of natural resources. **2 lectures**

Non-renewable and Renewable Energy Resources :

Conventional and non-conventional energy resources, Non-renewable energy resources : Kinds and economic potential of Oil and Natural gas, Coal and minerals reserves and future, Renewable energy resources : Solar, Wind, Tidal, Ocean, Geothermal and Nuclear energy, Biomass gasification, Biofuel, Energy from wastes, Global energy consumption patterns, Energy conservation and management, Energy outlook for sustainable future. …**7 lectures**

Water Resources:

Kinds of water resources (Fresh water, Marine, Estuarine, Wetland), Use and overuse of ground water, Conflict over water, water ecology, threats and management. Wetland functions in ecology and biodiversity, Wetland loss and degradation, Ramsar sites in India, Strategies for wetland conservation and management**.** **…….6 lectures**

Unit II

Biological resources:

Forest resources: classification and distribution of forests, forest degradation, deforestation and desertification and their impact on environment, current strategies of conservation and management of forest resources : Agro-forestry, Social forestry, Farm forestry. Joint Forest Management, Forest policy of India. **…….6 lectures**

Concept of livestock, livestock genetic resources biodiversity, sustainable livestock production, management of livestock under stressful environment, soil-plant-animal relationship, feed resources and Pasture conservation and management; strategies for wild life conservation and management, Conservation Management Areas (CMAs). **…….6 lectures**

Scope and importance of Human resource management, Employment and utilization of human as natural resources, Rural poverty and sustainable rural development, Human Development Index . **4 lectures**

Unit III

Soil and Land Resources :

Soil types, soil degradation, soil erosion, strategies for soil conservation and regeneration; land types, land use classification, land reform and land use planning and management. **…….5 lectures**

Approaches in Resource Management :

Ecological approach, Economic approach, Ethnological approach, Implications of the approaches, Integrated Resource Management strategies, Resource conflicts : Resource extraction, access and control, Environment Impact Assessment, Role of GIS in resource management, Participatory Resource Appraisal, Ecological footprint with emphasis on carbon footprint,National and International efforts in resource management. ……**9 lectures**

NATURAL RESOURCE MANAGEMENT (Practical)
BOT-H-CC20-7-P
Credit 1, marks 25, 15 lectures

1. **Workout / Experiment** **15 marks**
2. **Laboratory Records and Reports** **5 marks**
3. **Viva-voce** **5 marks**

1. Soil analysis : sample collection, analysis of soil texture and chemical tests, organic carbon content, measurement of field capacity
2. Water analysis : comparison of pH of different sources, salinity, TDS in various types of water sample
3. Estimation of solid waste generated by a domestic system (biodegradable and non-biodegradable) and impact on land degradation.
4. Measurement of woody species dominance using DBH (Diameter at Breast Height) methods
5. Biodiversity Indices calculation in a particular area
6. GPS surveying for field mapping
7. Preparation of natural resource management plans and reports on local environmental issues

Suggested Books

1. Harikesh N. Mishra, Managing Natural Resources, PHI Learning
2. B.S. Rathor and Vijoy Singh Rathor, Management of Natural Resources for Sustainable Development, Astral Publisher
3. Rabindranath Pati and Mitasree Mitra, Natural Resource Management, Abhijit Publication
4. Dr. Renu Devi, Natural Resource Management: Water, Forest and Land. Random Publication
5. Ramkrishna Mandal, Natural Resource Management under Sustainable Development, Discovery Publishing House Pvt.Ltd.
6. K.K. Singh, Natural Resources Conservation and Management, Prints Publication Pvt.Ltd.
7. Paul Cooper, Ecology and Natural Resource Management, Syrawood Publishing House
8. Leonel Nums & Luis Mignel Brito, Natural Resource Management, Our Knowledge Publishing,
9. M.K.Ghosh Roy, Renewable Energy, MED TECH Publishing

SEMESTER 8

RESEARCH METHODOLOGY-1
BOT-H-CC21-8-Th
Total marks 75; Credits 3, Class 45 hours

Unit I: Foundations of Research

Concept of Research: Definition, objectives, hypothesis, motivation. Types: Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, conceptual vs. empirical

…..4 lectures

Research Problem: Identification, necessity of defining the problem, techniques involved in defining a problem. …..4 lectures

Literature Review: Importance, sources (libraries, digital databases, academic search engines), and consolidation of previous work. …..4 lectures

Research Hypothesis: Null vs. Alternative Hypothesis, Type I and Type II errors, criteria for good hypotheses. …..2 lectures

Unit II: Research Design & Data Collection

Design of Experiments: Concepts, features of a good design. Experimental designs: Basic principles (Randomization, Replication, Local Control). …..4 lectures

Sampling Design: Steps in sampling, random vs. non-random sampling, sample size determination.

…..4 lectures

Data Collection Methods: Observation, Survey, Interview methods. Collection of primary vs. secondary data. …..4 lectures

Measurement Scales: Nominal, Ordinal, Interval, and Ratio scales. Validity and Reliability.

…..3 lectures

Unit III: Scientific Writing & Ethics

Scientific Writing: Types of research Articles- original articles, short communication, research article, review article. Structure of a research paper, thesis writing. Abbreviations, numbers, used nomenclature (ICN), and units. …..4 lectures

Presentation: Effective PowerPoint for oral and Poster presentations. …..4 lectures

Ethics & IPR: Academic integrity, plagiarism (detection tools and avoidance), self-plagiarism. Intellectual Property Rights (Patents, Copyrights, Traditional Knowledge). …..4 lectures

Reproduction of published material: Citation and Acknowledgement Reproducibility and accountability. …..2 lectures

Citations: Styles (APA, MLA, etc.), use of Reference Management Software (Mendeley/Zotero).

…..1 lecture

Research Data Management & Open Science: FAIR principles, data sharing and repositories.

…..1 lecture

RESEARCH METHODOLOGY-1
BOT-H-CC21-8-P
CREDIT 1, MARKS 25, LECTURES 15

1. Review Submission (Review size 20-25 pages): 10 marks
2. Presentation (8 minutes Power point presentation): 10 Marks
3. Viva: 5 marks

Introduction to scientific reviews, types and importance.

Review writing, submission and presentation:

Review must be checked for plagiarism before submission.

Suggested Textbooks:

1. Kothari, C.R. (2019). *Research Methodology: Methods and Techniques*. New Age International Publishers. (Standard text for fundamental concepts).
2. Creswell, J.W. & Creswell, J.D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. SAGE Publications.
3. Kumar, R. (2019). *Research Methodology: A Step-by-Step Guide for Beginners*. SAGE Publications.
4. Kothari, C.R. & Garg, G. (2019). *Research Methodology: Methods and Techniques*. New Age International.
5. Cochran, W.G. & Cox, G.M. (1992). *Experimental Designs*. Wiley.
6. Trochim, W.M.K. (2006). *The Research Methods Knowledge Base*. Atomic Dog Publishing.
7. Zar, J.H. (2010). *Biostatistical Analysis*. Pearson Education. (The "Gold Standard" for biological statistics).
8. Sokal, R.R. & Rohlf, F.J. (2012). *Biometry: The Principles and Practice of Statistics in Biological Research*. W.H. Freeman.
9. Rastogi, V.B. (2015). *Biostatistics*. Medtech.
10. Field, A. (2013). *Discovering Statistics Using IBM SPSS Statistics*. SAGE Publications.
11. Day, R.A. & Gastel, B. (2012). *How to Write and Publish a Scientific Paper*. Cambridge University Press.
12. CSE (Council of Science Editors). *Scientific Style and Format: The CSE Manual for Authors, Editors, and Publishers*.
13. Anderson, J., Durston, B.H. & Poole, M. (1970). *Thesis and Assignment Writing*. Wiley Eastern.
14. National Academy of Sciences. *On Being a Scientist: A Guide to Responsible Conduct in Research*.

RESEARCH METHODOLOGY-2
BOT-H-CC22-8-Th
Total marks 75; Credits 3, Class 45 hours

Unit I: General Laboratory Techniques: …..14 lectures

Lab Basics: Molarity, Normality, Molality. Preparation of percentage and ppm solutions. Buffer preparation.

Introduction **to Good Laboratory Practice (GLP):** Quality assurance, calibration, documentation standards.

Safety: Handling toxic chemicals, disposal protocols, and understanding reagent labels.

Principles and applications of common lab appliances: micropipettes, pH meter, Centrifuges (concept of rpm and g value), Colorimetry, luminometry fluorometry, and Spectrophotometry (Beer-Lambert law).

Preservation: concept of Fixation, Dehydration, Embedding in paraffin.

Sectioning: Microtomy (Rotary and Sledge), Free-hand sectioning, Epidermal peeling.

Staining: Classification of stains (Acidic, Basic), Double staining procedures, Mounting (whole mounts, smear, squash)

Unit II: Field Research and advanced tools: …..15 lectures

Field Data Collection: Quadrats, Transects (Line and Belt), Determination of Frequency, Density, Abundance, Importance Value Index (relative frequency, relative density, and relative dominance). Soil sampling, moisture measurement, canopy cover estimation. Plant physiological data collection (chlorophyll meter, fluorometer basics).

Documentation: Art of field photography, application of scale bars, and Field notebooks.

Biodiversity Indices: Calculation of Simpson's and Shannon-Wiener indices. Microscopy: Principles of Light, Bright field, Dark field, Phase Contrast, and Electron Microscopy (SEM/TEM).

Model organisms in plant research: Concept of a model organism, their importance and limitations: E coli, *Saccharomyces, Neurospora, Arabidopsis, Physcomitrella, Brachypodium*.

Radio isotopes in modern biology: Types and application,

Unit III: Bioinformatics; …..16 lectures

Introduction: Definition, scope, and importance of bioinformatics.

Data Retrieval: Using Keywords and Accession numbers; understanding file formats (FASTA, GenBank).

Major Databases: Nucleic acid databases (NCBI and EMBL).

Specific Database applications: EcoCys (E coli), TAIR (Arabidopsis), Gramene (Grasses/Rice), Sol Genomics (Solanaceae)

Similarity Searching: Concept of Homology, Orthology, and Paralogy. BLAST (Blastn, Blastp, Blastx) – Principle and interpretation of E-values and scores.

Pairwise Alignment: Dot matrix, Dynamic programming (Needleman-Wunsch vs. Smith-Waterman basics).

Multiple Sequence Alignment (MSA): ClustalW, MUSCLE; application in identifying conserved domains/motifs.

Molecular evolution: Concept of molecular evolution; molecular clocks. Tree construction methods [Distance-based methods: UPGMA, Neighbour-Joining (NJ). Character-based methods: Maximum Parsimony (MP), Maximum Likelihood (ML)].

Software Application: Introduction to MEGA (Molecular Evolutionary Genetics Analysis) for tree construction and bootstrapping.

Primer Design: Principles of PCR primer design using tools like Primer3 or NCBI Primer-BLAST.
Protein Visualisation: Viewing 3D protein structures using Rasmol or PyMOL.
Gene Prediction: Basic concepts of ORF finding and gene annotation in plant genomes.

RESEARCH METHODOLOGY-2
BOT-H-CC22-8-P
CREDIT 1, MARKS 25, LECTURES 15

1. Grant submission: **10 marks**
2. Grant defense (Power point presentation): **10 marks**
3. Viva: **5 marks**

1. Concept of a research Grant, funding and thrust area.
2. Introduction to major funding agencies in India (SERB, DBT, MoEF, CSIR, State Agencies, Private bodies etc).
3. Grant submission: Introduction, Hypothesis, Objective, Review (3-4 pages only), Plan of work (year wise), Budget (recurring and non-recurring), Expected outcome, Alternative strategy, Bibliography.

Grant must be checked for plagiarism before submission.

Suggested Textbooks:

1. Wilson, K. & Walker, J. (2010). *Principles and Techniques of Biochemistry and Molecular Biology*. Cambridge University Press.
2. Barker, K. (2005). *At the Bench: A Laboratory Navigator*. Cold Spring Harbor Laboratory Press.
3. Plummer, D.T. (2004). *An Introduction to Practical Biochemistry*. Tata McGraw-Hill.
4. Ruzin, S.E. (1999). *Plant Microtechnique and Microscopy*. Oxford University Press.
5. Johansen, D.A. (1940). *Plant Microtechnique*. McGraw-Hill. (The classic reference).
6. Sanderson, J.B. (1994). *Biological Microtechnique*. Garland Science.
7. Krishnamurthy, K.V. (1988). *Methods in Plant Histochemistry*. S. Viswanathan Printers.
8. Misra, R. (1968). *Ecology Workbook*. Oxford & IBH Publishing. (Standard for Indian ecology fieldwork).
9. Michael, P. (1984). *Ecological Methods for Field and Laboratory Investigations*. Tata McGraw-Hill.
10. Magurran, A.E. (2004). *Measuring Biological Diversity*. Blackwell Publishing.
11. Sambrook, J. & Russell, D.W. (2001). *Molecular Cloning: A Laboratory Manual*. Cold Spring Harbor Laboratory Press.
12. Mount, D.W. (2004). *Bioinformatics: Sequence and Genome Analysis*. Cold Spring Harbor Laboratory Press.
13. Lesk, A.M. (2019). *Introduction to Bioinformatics*. Oxford University Press.
14. Xiong, J. (2006). *Essential Bioinformatics*. Cambridge University Press.
15. Hall, B.G. (2017). *Phylogenetic Trees Made Easy: A How-To Manual*. Sinauer Associates.

PLANT BREEDING
BOT-H-CC23-8-Th
Credit 3, marks 75 , lectures 45

1. Introduction to plant breeding :

Objectives of plant breeding, major activities and achievements in plant breeding, undesirable consequences and limitations of conventional plant breeding. …2 lectures

2. Relevance of genetics with plant breeding :

Modes of reproduction: vegetative/asexual and sexual mode of reproduction, self & cross pollination, self incompatibility, genetic basis of male sterility, Introduction of male sterility in crop plants, centres of origin of crop plants, Agro-biodiversity, domestication of crop plants and acclimatization, Introduction of genetic resources, Genetic basis of Heterosis and Hybrid Vigor, Inbreeding depression

….8 lectures

3. Breeding for self pollinated crop :

Selection: Mass selection, Pure line selection, Hybridization: Objectives, Techniques, consequences, F1 hybrid selection, Pedigree and Bulk method, Single Seed decent method, Back cross method, Use of Haploids in plant breeding, Multiline varieties …9 lectures

4. Breeding for cross pollinated crop :

Population Breeding, Recurrent selection, Synthetic varieties, Hybrid Varieties, Composite varieties,

…4 lectures

5. Other Approaches of Breeding

Clonal selection for vegetatively propagated plants, Mutation Breeding : techniques, Achievements and limitation, Polyploid Breeding: Autopolypoid and allopolyploid in crop improvement, procedure, achievements and limitations, Distant Hybridization: significance, achievements& limitation.

….6 lectures

6. Achievements Through Conventional Plant Breeding

Breeding for Biotic stress (Disease and Insect), Breeding for Abiotic stress (Drought, Salinity and Temperature), Breeding for nutritional Quality (Protein, oil, Vitamin). ….4 Lectures

7. Molecular marker and their application in Plant breeding

Genetic Markers : RFLP, RAPD, AFLP, SCAR, SSR, ISSR, SNP, Allele specific marker, Trait phenotyping; Application in Evaluation of Genetic purity of parental lines, Germplasm characterization and conservation, Marker assisted selection, Achievements with MAS, limitations.

….8 lectures

8. **Release of new Seed Varieties**:

Testing of Seeds, Seed multiplication, Maintenance breeding, Plant Breeder's rights and regulations for plant variety protection. ….3 lectures

PLANT BREEDING
BOT-H-CC23-8-P
CREDIT 1, MARKS 25, LECTURES 15

1. Demonstration/experiment	**15 marks**
2. Laboratory workbook	**5 marks**
3. Viva-voce	**5 marks**

Experiments:

1. Study of floral reproductive parts in reference to self pollinated and cross pollinated plants
2. Demonstration of Emasculation and hybridization techniques adopted for self pollinated (Rice / Legumes/ Solanum / Bhindi) and cross pollinated (Maize or Cucurbita) plants
3. Determination of pollen sterility for male sterile line identification (Aceto carmine /TTC Staining)
4. Determination of pollen viability through pollen tube germination method
5. Selection of characters in hybrid population and Data collection procedure
6. Estimation of Heterosis and Inbreeding depression in a hybrid population
7. Layout for different yield trials(RBD, CRD and LSD)
8. Gene and Genotype frequency calculation in a population

Suggested Books:

1. R.W.Allard, Principles of Plant Breeding, Oxford & IBH Publishing Co. Pvt. Ltd.(2^{nd} Edn) (An Indian adaptation)
2. R.W.Allard, Principles of Plant Breeding, John Willey (2022)
3. B. D. Singh, Plant Breeding, Principles and Methods, Kalyani Publishers (12^{th} Ed.)
4. Praveen Kumar Saxena and K.R. Balabhaskar Modern Plant Breeding, Campus Books International (2014)
5. Phundan Singh, Essentials of Plant Breeding, Kalyani Publishers
6. Shabir H Wani & C.P. Malik, New Plant Breeding Techniques, Pointer Publisher

STRESS BIOLOGY
BOT-H-CC24-8-Th
Total marks 75; Credits 3, Class 45 hours

UNIT I

Introduction to stress biology: Definition of stress (Abiotic and Biotic) and stress biology, Types of stress, General stress response mechanism, Stress sensing mechanism in plants: calcium modulation, phospholipid signaling, concept of homeostasis and adaptation, stress tolerance vs stress avoidance. …..8 lectures

Abiotic stress in plants: Drought stress, salinity stress, Temperature stress, oxidative stress (ROS production, Role of ROS signalling in Stress tolerance and scavenging mechanism) …..7 lectures

UNIT II

Biotic stress in plants: plant pathogen interaction, plant defence response, Hypersensitive response, Systemic Acquired resistance, Pathogen recognition ,Defence signalling molecules (PR proteins) and Role of phytohormones (SA, JA, ethylene) in stress signaling. …..8 lectures

Molecular basis of stress response: Signal transduction, stress responsive genes, Role of transcription factors, Heat shock proteins and stress related metabolites. …..8 lectures

UNIT III

Stress adaptation mechanisms: Physiological adaptations, Morphological adaptations (changes in root-shoot ratios, aerenchyma development) and biochemical adaptations (accumulation of osmolytes, compatible solutes and antioxidant enzymes). …..8 lectures

Applications of stress biology: crop improvement for stress tolerance …..6 lectures

STRESS BIOLOGY
BOT-H-CC24-8-P
Credit 1, Marks 25, Lectures 15

1. Experiments	15 marks
2. Laboratory Records	5 marks
3. Viva	5 marks

1. Quantitative estimation of Phenol content in the seedlings in the absence and presence of biotic/abiotic stress.
2. Quantitative estimation of Proline content in the seedlings in the absence and presence of biotic/abiotic stress.
3. Catalase activity in the presence and absence of biotic/abiotic stress.
4. Comparative study of chlorophyll content in plants subjected to different degree of biotic/abiotic stress.

5. To study the effect of stress (salt/ water/ heavy metal) on seed germination and seedling growth (any commonly available specimen).
6. Study the mitotic index of onion in response to heavy metal stress.

Suggested Readings:

1. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). Plant Physiology and Development, 6th edition. New York, NY: Oxford University Press, Sinauer Associates.
2. Bhatla, S.C., Lal, M.A. (2018). Plant Physiology, Development and Metabolism. Singapore: Springer Nature, Singapore Pvt. Ltd.
3. Giri, B., & Sharma, M. P. (Eds.) (2021). Plant Stress Biology: Strategies and Trends. Springer Nature.
4. Buchanan, B. B., Gruissem, W., & Jones, R. L. (Eds.) (2015). Biochemistry and molecular biology of plants. John wiley & sons.
5. Jones, Ougham, Thomas and Waaland. 2013. The Molecular Life of Plants. First edition
6. Duane R. Hospenthal, Michael G. Rinaldi, Thomas J. Walsh (2023) Diagnosis and Treatment of Fungal Infections, Springer Nature
7. Sandeep Kumar Suman, Ajay Kumar Chandra and Pradeep Kumar (2019) Plant Stress Biology, New Delhi Publishers.

INDUSTRIAL MICROBIOLOGY
BOT-H-CC25-8-Th
Total marks 75; Credits 3, Class 45 hours

Unit I

Introduction, scope and historical development of industrial microbiology. Industrial importance of various microorganisms (in food, pharmaceuticals, fermentation etc). …..4 lectures

Bioreactors/ Fermenters and fermentation process: solid- state and liquid-state (stationary and submerged) fermentations; batch, fed batch and continuous fermentations. Structure of stirred tank bioreactor, types of bioreactors- laboratory, pilot scale and production fermenters. Structure and applications of tower fermenter, fixed bed and fluidized bed bioreactors and air- lift Fermenter.

…..10 lectures

Unit II

Principles and approaches for high throughput screening of microbes for industrially important enzymes and bio-molecules. Media formulation and process optimization. Strain improvement by mutagenesis, protoplast fusion and transformation. Gene cloning in strain improvement.

…..8 lectures

Downstream processing; Principle, types and applications of filtration, centrifugation, cell disruption, solvent extraction, chromatography, precipitation and ultrafiltration, lyophilization, spray drying in Production isolation and purification. …..7 lectures

Unit III

Microbial production of industrial products: microorganisms involved, media, fermentation conditions, purification and estimation: amylase, lipase, organic acids (citric and glutamic acid), beer, ethanol and Penicillin. …..5 lectures

Immobilization of whole cells and enzymes, Methods of immobilization, advantages and applications of immobilization, large scale application of immobilized enzymes (glucose isomerase and penicillin acylase). …..7 lectures

Industrial waste management from distillery and antibiotic units. Basic concept of bioprocess economics. …..4 lectures

INDUSTRIAL MICROBIOLOGY
BOT-H-CC25-8-P
CREDIT 1, MARKS 25, LECTURES 15

1. **Experiment** **15 marks**
2. **Laboratory Records** **5 marks**
3. **Viva** **5 marks**

1. Effect of different concentrations of sucrose on yeast/bacteria growth.
2. Effect of different temperatures on yeast/bacteria growth.
3. Production of amylase by Bacillus and quantitative estimation of amylase by starch-iodine method.
4. Isolate microorganisms from soil for novel antibiotic production.
5. Compare production of citric acid using glucose and molasses as carbon source.

Books:

1. Industrial Microbiology (2000) by AH Patel, Macmillan Publishers India
2. Industrial Microbiology by Prescott & Dunns, AVI Publishing Company Inc.
3. Industrial Microbiology by Casida LE, New age International (P) Ltd.
4. Adams & Moss, Food Microbiology, Published by Royal Society of Chemistry, Cambridge, U.K.
5. Industrial Microbiology, Author- G. Reed.
6. Industrial Microbiology, Author- Agarwal And Parihar.
7. Biology of Industrial Microorganisms. A.L. Demain.
8. Principles of Fermentation Technology, Authors- Standbary, Whitaker and Hall.

RESEARCH INTERNSHIP
BOT-H-CC26-8-Th & BOT-H-CC26-8-P
(4 credits; 3Th + 1 viva)

Syllabus based on the area of Internship of individual students. To be decided mutually by the supervisor and the student.

Evaluation:

Continuous Evaluation by the supervisor:	**25 marks**
Report submission (Internal evaluation 25 + External evaluation 15)	**40 marks**
Presentation	**25 marks**
Viva	**10 marks**

DISSERTATAION/PROJECT
BOT-H-CC27-8-Th & BOT-H-CC27-8-P
(8 credits; 6Th+2Viva)

Syllabus based on the area of dissertation of individual students. To be decided mutually by the supervisor and the student.

Evaluation:

Continuous Evaluation by the supervisor:	**50 marks**
Report submission (Internal evaluation 50 + External evaluation 25)	**75 marks**
Presentation	**50 marks**
Viva	**25 marks**

Course Structure- 3 yr MDC
(NEP 2020) BOTANY
UNIVERSITY OF CALCUTTA

UNIVERSITY OF CALCUTTA

Course Structure- 3 yr MDC (NEP 2020) BOTANY

Semester	CC1	CC2	Minor	IDC	AEC	SEC	CVAC	Summer Internship	Credit
	Level 100								
1	BOT-MD-CC1-1-Th BOT-MD-CC1-1-P Plant Diversity	BOT-MD-CC1-1-Th BOT-MD-CC1-1-P Plant Diversity		Plants around us* (Th+Pr)		BOT-MD-SEC-1-Th BOT-MD-SEC-1-P Mushroom Cultivation Technology*** (Th+Pr)	1. ENVS 2. CV		21
2	BOT-MD-CC2-2-Th BOT-MD-CC2-2-P Plant Systematics	BOT-MD-CC2-2-Th BOT-MD-CC2-2-P Plant Systematics					1. ENVS 2. Central Pool	Summer Internship **	21
	Exit option								
	Level 200								
3	BOT-MD-CC3-3-Th BOT-MD-CC3-3-P Economic Botany	BOT-MD-CC3-3-Th BOT-MD-CC3-3-P Economic Botany	Plant Diversity (Th+Pr)						21
4	BOT-MD-CC4-4-Th BOT-MD-CC4-4-P Pharmacognosy & Ethnobotany	BOT-MD-CC4-4-Th BOT-MD-CC4-4-P Pharmacognosy & Ethnobotany	Plant Systematics (Th+Pr)					Summer Internship**	22
	BOT-MD-CC5-4-Th BOT-MD-CC5-4-P Plant Geography, Ecology & Evolution	BOT-MD-CC5-4-Th BOT-MD-CC5-4-P Plant Geography, Ecology & Evolution							
	Exit option								

	Level 300								
5	BOT-MD-CC6-5-Th BOT-MD-CC6-5-P Plant anatomy & Embryology BOT-MD-CC7-5-Th BOT-MD-CC7-5-P Cell Biology & Genetics	BOT-MD-CC6-5-Th BOT-MD-CC6-5-P Plant anatomy & Embryology	Economic Botany (Th+Pr) Pharmacognosy & Ethnobotany (Th+Pr)						20
6	BOT-MD-CC8-6-Th BOT-MD-CC8-6-P Plant Physiology & Biochemistry	BOT-MD-CC7-5-Th BOT-MD-CC7-5-P Cell Biology & Genetics BOT-MD-CC8-6-Th BOT-MD-CC8-6-P Plant Physiology & Biochemistry	Plant Geography, Ecology & Evolution (Th+Pr) Plant anatomy & Embryology (Th+Pr)					Summer Internship**	20
Credits	**8**×4=32	**8**×4=32	**6**×4=24	**3**×3=9	**4**×2= 8	**3**×4=12	**4**×2=8	**1**×3=3	**128**
Marks	**8**×100=800	**8**×100=800	**6**×100=600	**3**×75=225	**4**×50 = 200	**3**×100=300	**4**×50=200		**Total Marks = 3200**

Marks = 25 marks per credit.
Total credit = 125 + 3 (for summer internship) = 128
*** IDC offered from Botany to be opted in 1st or 2nd or 3rd Semester**
****Summer Internship once after 2nd or 4th or 6th Semester.**
*****SEC to be opted in 1st or 2nd or 3rd Semester. In 1st semester when as Major 1, or in 2nd semester when as Major 2 or in 3rd Semester when as Minor.**

TO BE IMPLEMENTED FROM 2026 ACADEMIC SESSION

Course Structure- 3yr MDC (NEP 2020)

Semester 1

PLANT DIVERSITY
MBOT-CC1-1-T
Total marks 75; Credits 3, Class 45 hours

1. Introduction to plant kingdom.

1.1 Origin of life and evolution of plant cells, 1.2 Importance of plants as source of food, fuel and their role in ecosystem services (as carbon sink, sequestering etc.). (3 lectures)

2. Algae

2.1. Salient features of Cyanophyceae, Chlorophyceae, Charophyceae, Phaeophyceae, Rhodophyceae and Bacillariophyceae 2.2 Economic importance of algae in environment, agriculture, biotechnology and industry. (6 lectures)

3. Fungi

3.1 Salient features of Myxomycota, Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina, Deuteromycotina. 3.2 System of classification up to Sub-division (Ainsworth, 1973), 3.3 Economic importance of fungi (food, medicine and agriculture), 3.4 Fungal symbioses: Mycorrhiza, Lichen and their importance. (6 lectures)

4. Bryophytes

4.1 Salient features of Hepaticopsida, Anthocerotopsida and Bryopsida, 4.2. System of classification up to Class (Proskauer 1957), 4.3 Amphibian nature of bryophytes, 4.4 Economic and ecological importance. (6 lectures)

5. Pteridophytes

5.1 Salient features of Psilophyta, Lycophyta, Sphenophyta and Filicophyta, 5.2 System of classification up to Division (Gifford & Foster 1989), 5.3 Economic importance (food, medicine & agriculture). (6 lectures)

6. Gymnosperms

6.1 Salient features of Cycadophyta, Coniferophyta and Gnetophyta, 6.2 Outline classification up to Division: Progymnospermophyta to Gnetophyta (Gifford & Foster 1989), 6.3 Economic importance (wood, resin, essential oil & drugs). (6 lectures)

7. Angiosperms

7.1 Types and morphology of leaf, stem and root, 7.2 Inflorescence types with examples, 7.3 Flower: Different parts and forms of calyx, corolla, androecium and gynoecium; aestivation and placentation, 7.4 Types with examples-fruits and seeds. (12 lectures)

PLANT DIVERSITY
MBOT-CC1-1-P
Total marks 25; Credit 1, Class 30 hours

1.	**Work out: Morphology**	**10 marks**
2.	**Identification with reasons (other groups except angiosperms)**	**5 marks**
3.	**Class room performance (Practical notebook)**	**3 marks**
4.	**Field notebook**	**2 marks**
5.	**Viva-voce**	**5 marks**

1. Flower- dissection, drawing and study.

a) Different parts, b) Adhesion and cohesion, c) Placentation, d) Aestivation

2. Study of ovules: types (Fresh specimens/ permanent slides/ photographs)

3. Fruits: different types- study from fresh/ preserved specimens

4. Inflorescence types: study from fresh/ preserved specimens

5. Identification on the basis of reproductive and structural features from preserved specimens/ permanent slides: Algae (*Nostoc*, *Oedogonium* and *Ectocarpus*), Fungi (*Rhizopus*, *Ascobolus* and *Agaricus*), Bryophytes (*Marchantia*, *Anthoceros* and *Funaria*), Pteridophytes (*Selaginella*, *Equisetum* and *Pteris*), Gymnosperms (male cone and female cone/ megasporophyll of *Cycas*, *Pinus* and *Gnetum*).

6. A field notebook supported with photographs ONLY taken during field study to be submitted giving comprehensive idea about different types of inflorescence, flowers and fruits.

Textbook Reference:

1. Ganguli,H.C., Das, K.S.K. & Dutta, C.T. College Botany, Vol. I, latest Ed., New Central Book Agency

2. Ganguli,H.C. and Kar, A.K. College Botany, Vol. II, latest Ed., New Central Book Agency

3. Mukherjee, S. College Botany, Vol. III, latest Ed., New Central Book Agency

4. Uno, Storey& Moore, Principles of Botany, 2001, McGraw Hill.

5. Kenrick,P. & Crane, P. The Origin & early diversification of land plants (1997), Smithsonian Institute Press.

6. Bell, P.R. & Hensley, A.R. Green plants; their Origin & Diversity (2nd ed.), 2000, Cambridge University Press.

7. Frenchel, T. The origin & early Evolution of life, 2002, Oxford University Press.

8. Hait, G., Ghosh, A. and Bhattacharya, K. A Text Book of Botany (Vols. I, II & III), 2007, New Central Book Agency

9. Lock, A.J., & Evans, D.E., Plant Biology, 2001, Viva Books

10. Mitra, D., Guha, J. &Chowdhuri, S.K. Studies in Botany (Vols. I & II), Latest Ed., Das Printers

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

SEC (To be opted in 1st or 2nd or 3rd Semester)

MUSHROOM CULTIVATION TECHNOLOGY (THEORY)

MBOT- SEC-1-Th
Total marks 75; Credits 3, Class 45 hours

1. 1.1 Introduction, History of mushroom cultivation,1.2 Current overview of mushroom production in the world, 1.3 Mushroom biology-classification of mushrooms, edible mushrooms in India, poisonous mushrooms, mushroom poisoning.

(6 lectures)

2. 2.1 Infrastructure-structural design and layout of mushroom farm, substrates (locally available), 2.2 Appliances- weighing balance, autoclave, laminar air flow, incubator, hot air oven, spirit lamp, Bunsen burner, pH meter, laboratory heater, low-cost stoves, water bath, humidifier, water sprayer, vessels, inoculation hook and inoculation loop, sieves, culture racks, tray, polythene bags, 2.3 Methods of sterilization.

(9 lectures)

3. 3.1 Cultivation technology-overview of cultivation strategies, composting technology in mushroom production, mushroom bed preparation, culture media, pure culture, maintenance and preservation of pure culture, 3.2Production of spawn- cultivation of oyster mushroom, paddy-straw mushroom, milky mushroom and white button mushroom, 3.3 Cultivation of medicinal mushroom (Cordyceps and Ganoderma).

(12 lectures)

4. 4.1 Mushroom diseases and management strategies, 4.2 Post-harvest technology-short-term storage (Refrigeration- up to 24 hours), long-term storage (canning, pickles, papads etc.), drying, storage in salt solutions, 4.3 Food preparations from mushrooms.

(9 lectures)

5. 5.1 Uses of spent mushroom substrate, 5.2Strain improvements in cultivated mushroom; Nutritional and medicinal value of edible mushrooms, 5.3 Research centres- National level and regional level, 5.4 Cost-benefit ratio, 5.5Mushroom based Industry, 5.6 Mushroom market in India and abroad.

(9 lectures)

MUSHROOM CULTIVATION TECHNOLOGY
MBOT-SEC-1-P
Total marks 25; Credits 1, Class 30 hours

1.	Work out:	15 marks
2.	Class room performance (Practical notebook)	5 marks
3.	Viva-voce	5 marks

1. Macro identification of some common edible mushrooms (*Agaricus, Pleurotus*)
2. Media preparation and Fungal tissue culture
3. Sub-culturing for maintenance of culture
4. Spawn production
5. Cultivation of *Pleurotus*/*Calocybe*

Textbook Reference:

1. Acharya,K., Roy, A. & Sarkar, J. Mushroom Cultivation Technology, 2020, Techno World, Kolkata.
2. Marimuthu, T., Krishnamoorthy, A. S., Sivaprakasam, K. &Jayarajan, R. Oyster Mushrooms, 1991, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
3. Swaminathan, M. Food and Nutrition, 1990, Bappco, The Bangalore Printing & Publishing Co. Ltd.
4. Tewari, P. &Kapoor, S.C. Mushroom Cultivation, 1988, Mittal Publications, Delhi
5. Bahl, N. Handbook of Mushrooms, Ed. II, Vol I & Vol II

Semester 2

PLANT SYSTEMATICS (THEORY)

MBOT-CC2-2-Th

Total marks 75; Credits 3, Class 45 hours

1. Introduction:

Components of Systematics: Nomenclature, Identification, Classification; 1.2. Taxonomy and its phases - Pioneer, Consolidation, Biosystematic and Encyclopaedic; alpha- and omega- taxonomy, 1.3 Nomenclature: Type method, Publication, Rank of taxa, Rules of priority, Retention and rejection of names, Author Citation, Effective and valid publication, Elementary knowledge of ICN- Principles.

(10 lectures)

2. Systems of classification:

2.1 Broad outline of Bentham & Hooker (1862-1883) and Takhtajan (1997)- systems of classification with merits and demerits. 2.2 Systematics in Practice: Herbaria and Botanic Gardens – their role in teaching and research; 2.3. Dichotomous keys – indented and bracketed. 2.4 Brief idea on Phenetics and cladistics: Monophyletic, polyphyletic and paraphyletic groups; Plesiomorphy and apomorphy; 2.5 Numerical taxonomy- methods and significance;

2.6 Data sources in Taxonomy: Supportive evidences from Phytochemistry, Cytology, Palynology and Molecular biology data

(20 lectures)

3. Systematic study of angiosperm taxa: Diagnostic features, systematic position (Bentham & Hooker) and economically important plants (parts used and uses) of the following families:

3.1. Monocotyledons: Gramineae (Poaceae), Palmae (Arecaceae), Liliaceae, Musaceae, Zingiberaceae, Orchidaceae.

3.2. Dicotyledons: Magnoliaceae, Leguminosae (subfamilies), Euphorbiaceae, Malvaceae, Umbelliferae (Apiaceae), Labiatae (Lamiaceae), Solanaceae, Acanthaceae, Rubiaceae, Cucurbitaceae, Compositae (Asteraceae).

(15 lectures)

PLANT SYSTEMATICS (PRACTICAL)
MBOT-CC2-2-P
Total marks 25; Credit 1, Class 30 hours

1.	Work out on angiosperms	10 marks
2.	Spot Identification	3 marks
3.	Class room performance (Practical notebook)	2 marks
4.	Field records (field notebook, herbarium specimens)	5 marks
5. Viva-voce		5 marks

ANGIOSPERMS

1. Work out, description, preparation of floral formula and floral diagram, identification up to genus with the help of suitable literature of wild plants and systematic position according to Benthum and Hooker system of classification from the following families: Malvaceae, Leguminosae (Papilionaceae), Solanaceae, Acanthaceae, Labiatae (Lamiaceae), Rubiaceae.

2. Spot identification (Binomial, Family) of common wild plants from families included in the theoretical syllabus .

FIELD WORK

1. Visit to Acharya Jagadish Chandra Bose Indian Botanic Garden (Shibpur, Howrah) and Central National Herbarium (CNH).
2. One Local and one long excursion in different phytogeographic zone or Two Local excursions.

FIELD RECORDS

1. Field Note Book (authenticated) with field notes on the plants of the area of excursion and voucher specimen book.

2. Herbarium specimens: Preparation of 10 angiospermic specimens (identified with author citation, voucher number and arranged following Bentham and Hooker system of classification) to be submitted during examination.

Textbook References:

1. Paria, N.D., Plant Taxonomy & Biodiversity, 2022, Santra Publication Pvt. Ltd.

2. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. and Donoghue, M.J. Plant Systematics, A Phylogenetic Approach (4th ed.), 2016, SinauerAssociaties, Inc.

3. Jones, S.B. and Luchsinger, A.E. Plant Systematics (2nd ed.), 1987, McGraw Hill Book Company

4. Singh, G. Plant Systematics: An Integrated Approach (3rd ed.), 2016, CRC Press

5. Sambamurty, A.V.S.S. Taxonomy of Angiosperms, 2005, I.K. International Pvt. Ltd.

6. Sivaranjan, V.V. Principles of Plant Taxonomy (2nd ed.), 1991, Oxford & IBH

7. Subrahmanyam, N.S. Modern Plant Taxonomy, Latest Ed., Vikas Publishing House

8. Naik, V.N. Taxonomy of Angiosperms, Latest Ed., Tata McGraw Hill

9. Stace, C. A Plant Taxonomy & Biosystematics, Latest Ed., Arnold Publishers

10. Mitra, J.N. An Introduction to Systematic Botany & Ecology, Latest Ed., World Press

11. Dutta, S.C. Systematic Botany, Latest Ed., Wiley Eastern.

12. Lawrence, G.H.M. Taxonomy of Vascular Plants Ed., Oxford & IBH.

13. Prain, D. Bengal Plants (Vol I & II), Bishen Singh Mahendra Pal Singh.

14. Jeffrey, C. An Introduction to Plant Systematics, Latest Ed., Allied Publishers Pvt. Ltd.

15. Radford. A.B. Fundumentls of Plant Systematics, Latest Ed., Harper & Row.

16. Simpson, G. Plant Systematics, 2006, 2010, 2019, Springer.

17. Bhattacharya, B. Systematic Botany, 2006, Narosa Publishing House.

18. Heywood, V.H. Plant Taxonomy 1967, Edward Arnold, London.

19. Cronquist, A. The Evolution & Classification of Flowering Plant, 1988 (2nd ed.), New York Bot. Garden Bronx. New York.

20. Cronquist, A. An Integrated System of Classification of Flowering Plants.1981. Bishen Singh Mahendra Pal Singh.

21. Subramanyam, N.S. Laboratory Manual of Plant Taxonomy (2nd ed.) 1999, Vikas Publishing House.

22. Heywood, V.H. Flowering Plants of the World 1978, Oxford University Press.

IDC in BOTANY (To be opted in 1st or 2nd or 3rd semester)

PLANTS AROUND US (THEORY)

Total marks 50; Credits 2, Class 30 hours

Introduction: Introduction to plant groups: Algae, Bryophytes, Pteridophytes, Gymnosperms, Angiosperms (Monocot and Dicot); Fungi -general characters; Contributions of Theophrastus, Charak, Sushruta, Linnaeus, Mendel and J.C. Bose. ……..5 lectures

Plant body: Plant cell and tissue; Morphology of root, stem, leaf, flower, fruit and seed. ..…5 lectures

Plants and ecosystem: Phytodiversity and conservation; Biodiversity hotspots of India; Forest types in India; Plant-based adaptations to climate change; Concept of 'Carbon footprint'- role of plants in reducing carbon footprint. ……..5 lectures

Plants and society: Plants in day-to-day life (brief general information including uses)-major cereals (rice, wheat and maize); pulses (mung and pea); Oil (mustard and coconut); Sugar (sugarcane and beet root); Vegetables (potato, brinjal, ladies finger and spinach); Fruits (apple, banana, guava, mango and jackfruit); Beverages (tea, coffee, beer and wine); Plants as timber (sal and teak); Non-timber- energy (fossil and non-fossil), resin, honey and essential oil (lavender and citronella oil); Fiber (jute and cotton); Ornamental plants (rose, marigold, tuberose, gulmohar, jarul, kalanchoe); Importance of bacteria *(Lactobacillus, E. coli* and *Rhizobium)* and Fungi *(Phytophthora, Agaricus* and *Penicillium).* …..10 lectures

Plants and human health: Important medicinal plants and their uses- basak *(Justicia adhatoda),* ghritakumari *(Aloe vera),* cinchona *(Cinchona officinalis),* neem *(Azadirachta indica),* kalmegh *(Andrographis paniculata),* pudina *(Mentha arvensis),* tulsi *(Ocimum sanctum),* sarpagandha *(Rauvolfia serpentina);* Plant-derived medicinal compounds and uses (Quinine, Reserpine, Vincristine, Curcumin, Gingerol). …….5 lectures

Plants Around Us

Total marks 25; Credit 1, Class 30 hours

1. Workout: Dissection of plants 10 marks
2. Spot Identification 6 marks
3. Practical notebook 4 marks
4. Viva-voce 5 marks

- Identification: Morphological study of plant specimens
- Microscopic study - *Nostoc, Oedogonium* (with oogonium), *Rhizopus, Penicillium* (sporangiophore). Macroscopic study - *Agaricus* (fruit body), *Marchantia* with gemma cup, antheridiophore/ archaegoniophore, Moss sporophyte, *Pteris* (fertile leaf/pinna), *Pinus* - male and female cone.
- Fruits of tomato, peas, cucumber, citrus, apple & banana.
- Work out of flower: Floral parts of *Hibiscus rosa-sinensis, Clitoria ternatea* & *Datura metel.*

Textbook references:

1. Studies in Botany (vol-I)- J.N.Mitra, Debabrata Mitra & Salii Chowdhury (Moulik Library)
2. A Textbook of Botany (Vol. 1)- G. Hait, K. Bhattacharya & A. K. Ghosh (New Central Book Agency)
3. Udvid Bigyan (Vol-I) (Bengali)- S. Chowdhury, N. Datta, D. Mitra & J. Guha (Moulik Library)
4. College Botany (vol 11)-H.C. Gangulee, A.K. Kar, S.C. Santra (New Central Book Agency)
5. Snatak Udvidbidya (Semester 1)- Dr. Jayanta Kumar Sikdar, Dr. Kunal Sen, Dr. Pranab Giri (Santra Publication)

Semester 3

ECONOMIC BOTANY

MBOT-CC3-3-T

(Total Marks 75, Credits 3, Lectures 45 hours)

1. **Introduction:** Concepts of centre of origin, their importance with reference to Vavilov's work, Importance of germplasm diversity. **4 Lectures**

2. **Cereals, pulses and oils:**

2.1 Cereals: Rice and Wheat- cultivation, processing and uses, Millets as future cereals. 2.2 Pulses and Legumes: Cultivation and uses of Gram and Mung Bean - Importance to man and environment, 2.3 Oil and fats: General description, classification, extraction, uses and health implications of Mustard and Coconut (Botanical name, family and uses). Essential oils- general account, extraction methods and their uses.

12 Lectures

3. Sugar, starch, spices and beverages:

3.1 Processing of sugarcane to products and byproducts. 3.2 Spices and condiments: Scientific names, family, economically important parts and uses of Ajwain, Cumin, Black Cumin, Mustard, Fenugreek, Coriander, Chillies, Bay leaf, Black Pepper, Cardamom (small and big), Clove, Cinnamon, Onion, Garlic and Ginger, 3.3 Beverages: Tea and coffee (plant habit, processing and uses).

9 Lectures

3. **Narcotics, timbers and fibres:**

4.1 Habit forming drugs with special reference to *Cannabis* and Tobacco (processing, uses and health hazards), 4.2 Timber: General account with special reference to Sal and Teak, 4.3 Fibers: Cotton and Jute - (extraction and uses). **16 Lectures**

5. **Vegetables and fruits:**

5.1 Vegetables: Scientific names, family and edible parts- Potato, Pointed gourd, Brinjal, Tomato, Cauliflower, Cabbage, Lady´s finger, Ridge gourd, Cucumber, Spinach, Carrot, Pea, Beans, Drumstick, Radish and Sweet potato, 5.2 Fruits: Scientific names, family, types of fruits and edible parts: Mango, Papaya Custard apple, Pineapple, Tamarind, Jackfruit, Banana, Guava, Pomegranate, Apple, Strawberry, Wood apple, Litchi and Grapes. 4 **Lectures**

ECONOMIC BOTANY

MBOT-CC3-3-P

(Total Marks 25, Credits 2, Class 30 hours)

1. Identification (2× 6)	**12 marks**
2. Practical notebook	**4 marks**
3. Field notebook	**4 marks**
4. Viva voce	**5 marks**

1. Identification of economically important plants (as listed below) from fresh/ herbarium sheets/ preserved specimens:

Cereals: Rice and Wheat

Legume: Gram, (habit, fruit and seed structure) Spices and condiments: Coriander, Cumin, Bay leaf, Black pepper, Cinnamom Tea and coffee (plant habit and parts used)

Common vegetables: Potato, Cucumber, Brinjal, Lady´s finger, Carrot, Sweet potato Fruits (only identify the type of fruit) as listed in theoretical syllabus

Fibres: jute and cotton (plant and parts used)

2. Field record must be properly authenticated by escorting teacher and supported by photographs of the field

Text book References:

1. Mukherjee, S. College Botany, Vol. III, latest Ed., New Central Book Agency
2. Mitra, D., Guha, J., Chowdhuri, S.K. Studies in Botany, Vol. II, latest Ed. D.N. Moulik for Moulik Library.
3. Kochhar, S.L. 2012. Economic Botany in Tropics, MacMillan & Co. New Delhi, India.
4. Simpson, B.B. and Conner-Ogorzaly, M. 1986. Economic botany: plants in our world.
5. Pandey, B.P. 1978. Economic botany for degree honours and postgraduate students.
6. Albert F. Hill 1952. Economic botany: a textbook of useful plants and plant productions, 2nd Edn.

PHARMACOGNOSY & ETHNOBOTANY

MBOT-CC4-4-T
(Total Marks 75, Credits 3, Lectures 45 hours)

Medicinal botany: History, scope and importance of medicinal plant in herbal drug industry, a brief idea about traditional systems of medicine- ayurveda, siddha and unani, Polyherbal formulations.

3 Lectures

Pharmacognosy- General account : Pharmacognosy and its introduction and importance in modern medicine, Crude drugs, Classification of plant drugs- chemical and pharmacological action, Drug evaluation– organoleptic, microscopic, chemical, physical and biological, Major pharmacological groups of plant drugs and their uses, Conservation of endangered and endemic medicinal plants.

12 Lectures

Secondary metabolites: Secondary metabolites and their differences with primary metabolites, Major types and classification–terpenoids, phenolics, flavonoids, alkaloids and their pharmacological importance. **10 lectures**

Pharmacologically active constituents:

Source plants (one example) parts used and uses of: Steroids (Solasodin, Diosgenin, Digitoxin), Tannin (Catechin), Resins (Gingerol, Curcuminoids), Alkaloids (Quinine, Atropine. Pilocarpine, Strychnine, Reserpine, Vinblastine, Taxol, Pyrolizidine), Phenols (Sennoside and Capsaicin). **4 lectures**

Ethnobotany and folk medicine: Definition, methods of study, application, Indian scenario, national interacts, folk medicines in ethnobotany, ethnomedicine, ethnoecology, ethnic communities of India, sacred groves, application of natural products to certain diseases- Jaundice, cardiac, infertility, diabetes, blood pressure and skin diseases. **15 lectures**

PHARMACOGNOSY & ETHNOBOTANY

MBOT-CC4-4-P

Total Marks 25; Credit 1, Class 30 hours

1. Workout	**12 marks**
2. Identification from fresh specimen/ herbarium	**5 marks**
3. Laboratory Records	**3 marks**
4. Viva-voce	**5 marks**

1. Chemical tests for (a) Tannin (*Camellia sinensis* / *Terminalia chebula*), (b) Alkaloid (*Catharanthus roseus*).
2. Powder microscopy – *Zingiber* and *Holarrhena*.
3. Histochemical tests of (a) Curcumin (*Curcuma longa*), (b) Starch in non-lignified vessel (*Zingiber*),

(c) Alkaloid (stem of *Catharanthus* and bark of *Holarrhena*).

4. Identification from fresh specimen/ herbarium of some commonly used medicinal plants:

a. *Azadirachta indica* (Neem), b. *Justicia adhatoda* (Vasak), c. *Andrographis paniculata* (Kalmegh), d. *Saraca asoca* (Ashoka), e. *Centella asiatica* (Thankuni), f. *Catharanthus roseus* (Nayantara), g. *Phyllanthus emblica* (Amla), h. *Terminalia chebula* (Haritaki),i. *Bacopa monnieri* (Brahmi).

Textbook References:

1. Trease & Evans. Pharmacognosy, Saunders.
2. Trivedi P.C. 2006. Medicinal Plants: Ethnobotanical approach, Agrobios India
3. S.K. Jain, 1995. Manual of Ethnobotany, Scientific Publishers, Jodhpur.

Plant Geography, Ecology and Evolution
MBOT-CC5-4-T

(Total Marks 75, Credits 3, Lectures 45 hours)

PLANT GEOGRAPHY (15 marks)

Phytogeographical regions: Phytogeographical regions of India (Chatterjee 1960); Dominant flora of Eastern Himalaya, Western Himalaya, Indian deserts and Sundarban. **5 lectures**

Endemism:.Endemism types and Factors; Age & Area hypothesis and Epibiotic theory; Endemism in Indian flora. **4 lectures**

ECOLOGY (30 marks)

Preliminary idea on: Habitat and Niche (fundamental and realized), Ecotone and Edge–effect, Microclimate, Ecads, Ecotypes and Ecoclines, Carrying capacity. **3 lectures**

Community ecology: Community- Characteristics and diversity (α, β, γ), Ecological succession –Primary and secondary, Seral stages (with reference to Lithosere and Hydrosere), autogenic and allogenic succession, Climax community. **4 lectures**

Plant indicators (metallophytes); Phytoremediation. **3 lectures**

Conservation of Biodiversity: Level of Biodiversity: genetic, species & ecosystem diversity, Biodiversity hot spots- criteria, Indian hotspots, *In- situ* and *ex-situ* conservation, Causes of extinction, IUCN Red List categories, Seed-banks,. Cryopreservation, Geographic Information System and Remote Sensing (brief idea). **10 lectures**

EVOLUTION (30 marks)

Introduction, Theories of evolution: Evidences, Natural selection, Group selection, Neutral theory of molecular evolution, Phyletic gradualism, Punctuated equilibrium and Stasis **8 lectures**

Brief idea on: Stabilizing directional, disruptive and sexual selection; Speciation: Sympatric and Allopatric; Coevolution, Adaptive radiation, Reproductive isolation. **8 lectures**

Plant Geography, Ecology and Evolution

MBOT-CC5-4-P

(Total Marks 25, Credit 1, Class 30 hours)

1. Work out on ecological parameters	**12 marks**
2. Lab records	**5 marks**
3. Field note book	**3 marks**
4. Viva-voce	**5 marks**

PLANT GEOGRAPHY

1. Study of local flora and submission of a project report highlighting phytogeographical characteristics of the region.

ECOLOGY

1. Study of community structure by quadrat method and determination of (i) Minimal size of the quadrat, (ii) Estimation of frequency, density and abundance (to be done during excursion/ field visit).
2. Estimation of foliar dust deposition.
3. Determination of chemical properties of soil by rapid spot test (carbonate, iron, nitrate)

Textbook

Ecology & Plant Geography

1. Chapman and Riss. Ecology: Principles and Applications, Latest Ed., Cambridge University Press
2. Shukla, R.S. &Chandel, P.S. Plant Ecology, Latest Ed., S. Chandel and Co.
3. Kumar, H.D. Modern Concept of Ecology, Latest Ed. Vikas Publishing House
4. Begon, M., Herper, J.L. and Townsend, C.R. Ecology- Individuals, Populations and Communities (3rd ed.), Oxford Blackwell Science
5. Verma, P.S. & Agarwal, U.K. Concept of Ecology, Latest Ed., S. Chand & Company
6. Odum, F.P. Fundamentals of Ecology, Latest Ed., Saunders
7. Sharma, P.D. Elements of Ecology, Latest Ed., Rastogi Publications
8. Ambasht, R.S. & Ambasht, N.K. A Text Book of Plant Ecology, Latest Ed., CBS Publication & Distributors
9. Mani, M.S. Bio-Geography of India, Latest Ed., Springer-Verlag.
10. Mackenzie et al. Ecology, Latest Ed., Viva Books.

11. Gurevitch, J. (et al.)., The Ecology of plants, 2002, Sinauer Associates.

12. Kimar, U. &Asija, M.J. Bio-diversity: Principles & Conservation, 2005, Student Edition, Agrobios (India)

13. Krishnamurthy, K.V. An Advanced Text Book on Biodiversity, 2003, Oxford & IBH Publishing Co. Ltd.

14. Mitra, D., Guha, J.K., Chowdhury, S.K. Studies in Botany, Vol. II (7th ed.) Moulik Library.

15. Primack, R.B. Essentials of Conservation Biology, 1993, Sinauer Associates.

16. Lo, C.P. & Yeung, A.K.W. Concepts and Techniques of Geographic Information Systems, 2002, Printice-Hall of India.

17. Cain, Bowman, Hacker. Ecology. 2014. 3rd Ed. Sinauer Associates

Evolution

1. Futuyma., D. Evolution. 2015. (3rd Ed.) Sinauer Associates

2. Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Jane B. Reece. Campbell Biology. 2017. 11th Ed. Pearson

Semester 5

PLANT ANATOMY & EMBRYOLOGY
MBOT-CC6-5-Th
(Total Marks 75, Credits 3, Lectures 45 hours)

PLANT ANATOMY (50 marks)

Cell and Tissues: 14 lectures

Cell wall: ultrastructure, chemical constituents; thickening of cell wall. Tissues: meristems, simple and complex tissues, cambium- Structure and function, Mechanical tissues and the principles governing their distribution in plants. Stele: stelar types; leaf-trace and leaf-gap, Stomata types (Metcalfe and Chalk, 1950; Stebbins and Khush, 1961).

Primary and secondary growth: 8 lectures

Primary structure of stem and root- monocot and dicot. Leaf- dorsiventral and isobilateral, Secondary growth: normal (intra- & extra-stelar),

Developmental and Ecological Anatomy: 6 lectures

Organization of shoot apex (Tunica–Corpus) and root apex (Korper-Kappe),plastochron, Adaptive anatomical features of hydrophytes, xerophytes, halophytes.

Scope of plant anatomy: 2 lectures

Application in systematics, forensics and pharmacognosy.

EMBRYOLOGY (25 marks)

Pre-fertilisation and post- fertilization changes : 10 lectures

Microsporogenesis and Microgametogenesis, Megasporogenesis and Megagametogenesis (monosporic, bisporic and tetrasporic), Pollen germination, Double fertilization, post-fertilization changes.

Embryo development and apomixis: 5 lectures

Embryogenesis in *Capsella*, Development of endosperm (3 types), Apomixis- Apospory and Apogamy, 2.4 Polyembryony- different types.

PLANT ANATOMY& EMBRYOLOGY
MBOT-CC6-5-P
Total Marks 25; Credit 1, Class 30 hours

1.Workout on Plant Anatomy	10 marks
2. Identification with reasons	5 marks
3.Classroom performance: Lab records	3 marks
Slides	2 marks
4. Viva– voce	5 marks

1. Microscopic studies on: Types of stomata, sclerenchyma and parenchyma cells, sclereids, raphides (*Colocasia*), cystolith (*Ficus* leaf) starch grains, aleurone grains, laticiferous ducts, oil glands.
2. Study of anatomical details through temporary stained mounts- a) Root-Monocot and dicot, b) Stem- Monocot and dicot, c) Leaf- Isobilateral and Dorsiventral,
3. Study of adaptive anatomical features: Hydrophytes (*Nymphaea* – petiole), Xerophytes (*Nerium* – leaf) and Epiphytic root (Orchid -velamen).

Textbook References:

PLANT ANATOMY

1. Fahn, A. Plant Anatomy (4th ed.), 1990, Wiley Eastern.
2. Eames, A.J. & Mac. Daniels, L.H. An Introduction to Plant Anatomy, Latest Ed., McGraw Hill
3. Esau, K. Anatomy of Seed Plants (2nd ed.), 1977, John Wiley & Sons
4. Pandey, B.P. Plant Anatomy, Latest Ed., S. Chand & Company
5. Tayal, M.S. Plant Anatomy, Latest Ed., Rastogi Publications
6. Roy, P. Plant Anatomy, Latest Ed., New Central Book Agency

EMBRYOLOGY

1. Raghavan, V. Molecular Embryology of Flowering Plants, 1997, Camb. University Press.
2. Maheswari, P. An Introduction to Embryology of Angiosperm, Latest Ed., Tata McGraw Hill.
3. Raghavan, V. Embryogenesis in Angiosperms: A Development & Experimental Study, 1986, Cambridge University Press.
4. Bhojwani, S.S. & Bhatnagar, S.D. The Embryology of Angiosperms (4th ed.), 1989, Publishing House.

CELL BIOLOGY and GENETICS
MBOT CC7-5-Th
Theoretical – 3 credits (marks 75) 45 lectures

Cell Biology

Nucleus and Chromosome: Ultrastructure of nuclear envelope, nucleolus and their functions, Chromatin ultrastructure and DNA packaging in eukaryotic chromosome (Nucleosome concept). Centromere: types, structure and function.. Ultrastructure of mitochondria, chloroplast, golgi complex, endoplasmic reticulum and their functions …8 lectures

Cell cycle and its regulation: Kinetochore and spindle apparatus-structural organization and functions, Microtubules- structure, organization and function, Mechanism of cell cycle control in Yeast (checkpoints and role of MPF), Apoptosis (Brief idea). …6 lectures

Genetics

Introduction: Mendelian genetics and its extension (incomplete dominance, codominance, multiple alleles), Epistasis (Dominant and Recessive epistasis) and polygenic inheritance in plants. … 4 lectures

Linkage, Crossing over and Gene Mapping: Complete and incomplete linkage,), linkage group, Crossing over, detection of crossing over (McClintock's experiment), Molecular mechanism of crossing over (Holliday model), Calculation of recombination frequencies, Gene mapping with three point test cross, Molecular mapping – ISH, FISH (brief idea) … 8 lectures

Chromosomal aberrations: Deletion, Duplication, Inversion & Translocation, Aneuploidy & Polyploidy-types, importance and role in evolution …4 lectures

Central Dogma: Transcription and Translation. Genetic Code – properties. … 4 lectures

Mutation: Point mutation (tautomerisation; transition, transversion and frame shift), Mutagen-physical and chemical. ….4 lectures

Structural organisation of Gene: One Gene–one polypeptide concept, Split gene, Overlapping gene, Repetitive DNA tandem and interspersed, Transposon (Ac-Ds system), Homoeotic gene in plants (ABCE Quartet model of flowering). .....7 lectures

CELL BIOLOGY and GENETICS
MBOT CC7-5-P

1. Work out	10
2.Identification	5
3.Classroom performance (Laboratory Records and slides)	3+2
4. Viva-voce	5

Cell Biology

1. Study of plant cell structure with the help of epidermal peel mount of Onion/Rhoeo
2. Measurement of cell size by the technique of micrometry.
3. Study of nucleolus through hematoxylin staining and determination of nucleolar frequency

Genetics

1. Introduction to chromosome preparation: Pre-treatment, Fixation, Staining, Squash and Smear preparation, Preparation of permanent slides.
2. Study of mitotic and meiotic chromosome: Identification of different stages and free hand drawings from the permanent slides of roots and flower buds*: Allium cepa*
3. Determination of mitotic index and frequency of different mitotic stages in pre-fixed root tips of *Allium cepa.*

Suggested Books:

1. Gupta, P.K. Cytogenetics, Rastogi Publications
2. Guha. J. & Chaudhuri, S.K. , Udvidbigyan: vol. II, Moulik Library (Bengali Version)
3. Jain, H.K. , Genetics , Oxford & IBH Publishing House
4. Kar, D.K. & Halder, S. Cell Biology, Genetics & Molecular Biology , New Central Book Agency
5. Sikdar, J.K., Sen, K. & Giri, P. , Prarambhik Udbhidbidya , Vol II, (Biomolecules and Cell Biology Genetics) , Santra Publication (Bengali Version)
6. Sen, S. & Kar, D. K., Cytology & Genetics , Narosa Publishing House
7. Santra. S.C. , Practical Botany, Vol II, New Central Book Agency

Semester 6

PLANT PHYSIOLOGY and BIOCHEMISTRY
MBOT-CC8-6-Th
(Total Marks 75, Credits 3, Lectures 45 hours)

Plant Physiology

Transport in plants and Transpiration: Ascent of sap and Xylem cavitation, Phloem transport and source-sink relation. Transpiration-Types, Mechanism of stomatal movement, significance.
…….8 lectures

Photosynthesis and Respiration: Photosynthesis: Pigments, Action spectra and Enhancement effect, Electron transport system and Photophosphorylation, C_3, C_4 and CAM photosynthesis, - Reaction and Significance. Respiration: Glycolysis & Krebs cycle— Reactions and Significance, ETS and Oxidative phosphorylation. …….10 lectures

Nitrogen metabolism: Biological dinitrogen fixation, Amino acid synthesis (reductive amination and transamination). ……4 lectures

Plant Growth regulators: Physiological roles of Auxin, Gibberellin, Cytokinin, Ethylene, ABA.
….5 lectures

Photoperiodism: Plant types, Role of phytochrome and GA in flowering and Vernalization.
…..4 lectures

Senescence (brief idea). …….2 lectures

Biochemistry

Molecules of life: Proteins- Primary, secondary and tertiary structure, classification of amino acids. Nucleic acid- DNA structure and types, RNA types, Carbohydrates - structure of mono-, di- and polysaccharide; stereoisomers, enantiomers and epimers. Lipids - Simple lipid and compound lipid (phospholipids and glycolipids), fatty acids- saturated and unsaturated.
....8 lectures

Enzyme -- Classifications with examples (IUBMB), Mechanism of action ….4 lectures

PLANT PHYSIOLOGY and BIOCHEMISTRY (PRACTICAL)

MBOT-CC8-6-P

Total Marks 25; Credit 1

1.Experiment on Plant Physiology	15 marks
2.Classroom performance: Lab records	5 marks
3. Viva voce	5 marks

Plant Physiology:

i) Experiment on Plasmolysis.

ii) Measurement of leaf area (graphical method) and determination of transpiration rate per unit area by weighing method.

iii) Imbibition of water by dry seeds -starchy, proteinaceous and fatty seeds.

iv) Determination of evolution of O_2 during photosynthesis (using graduated tube).

v) Determination of evolution of CO_2 during aerobic respiration.

Suggested Books:

1. Salisbury, F.B. & Ross, C.W. Plant Physiology (4th ed.), 19992, Wadsoworth Publishing Company.

2. Mukherjee, S. & Ghosh, A. Plant Physiology (2nd ed.), 2005, New Central Book Agency.

3. Mehta, S.L., Lodha, M.L. & Bane, P.V. Recent Advances in Plant Biochemistry, 1989. I.C.A.R.

4. Conn, E.E. and Stumpf, R.R. Outlines of Bio-Chemistry, Latest Ed., Wiley Eastern.

5. Lehninger Principles of Biochemistry. Sixth Edition. 2013. David L. Nelson, Michael M. Cox. Freeman, Macmillan.

Question pattern to be followed

For theoretical papers (75 marks)

1. **Short answer Type :**
   Six questions of 2 marks each, out of **nine** questions to be set
   (2x 6)

2. **Short Note type**
   Three questions of 5 marks each out of **five** questions to be set
   (5x3)

3. **Long Answer Type**
   Four questions of 12 marks each out of **six** questions to be set
   (12x4)

Note :

1. While setting the question the entire syllabus needs to be represented rationally in the question paper.
2. The questions are to be set from each section separately according to the marks distributed in each section, wherever applicable.
   For eg; Plant anatomy and Embryology;
   Plant Geography, Ecology and Evolution;
   Plant tissue culture and Horticulture etc.

For practical papers (25 marks)

Marks distribution to be followed as per given in each paper in syllabus.

Course Outcomes- Programme Outcomes- Programme Specific Outcomes (CO-PO-PSO)

Programme Outcomes

Knowledge outcomes:

After completing B.Sc. Botany Programme students will be able to:

PO1: demonstrate and apply the fundamental knowledge of the basic principles of major fields of biology;

PO2: Apply knowledge to solve the issues related to plant sciences with the help of different biological techniques

PO3: Apply knowledge for conservation of endemic and endangered plant species

Skill outcomes:

After completing B.Sc. Botany Programme students will be able to:

PO4: collaborate effectively on team-oriented projects in the field of life sciences.

PO5: communicate scientific information in a clear and concise manner both orally and in writing

PO6: explain Biodiversity and plant pathogenesis in relation to climate change

PO7: apply Biotechnology, Conservation techniques, Molecular Biological techniques and Plant breeding techniques in plant sciences

PO8: apply knowledge of Medicinal and Economic botany in day to day life.

PO9: apply the knowledge to develop the sustainable and eco-friendly technology in Industrial Botany

Generic outcomes:

Students will

PO10: develop their critical reasoning, judgment and communication skills.

PO11: augment the recent developments in the field of Molecular and cell Biology, Biotechnology, Computational Botany and relevant fields of research and development.

PO12: enhance the scientific temper within themselves so that to develop a research culture and implementation of the policies to tackle the burning issues at global and local level.

Programme Specific Outcomes

PSO1: Students get acquainted with techniques which are used in industrially for harvesting important plant products.

PSO2: Students get conceptual knowledge of entrepreneurships in Mushroom cultivation, Biofertilizers and Biopesticides production, Plant tissue culture laboratories, different propagation methods used in Horticulture, Enzyme production, Fermentation, Single cell proteins production, biofuel production etc.

PSO3: Understand the diversity of the plants and structural organization of plants starting from cryptogames as well as phanerogams like monocots and Dicot.

PSO4: Understand plant structures in the context of genetical , physiological and biochemical functions of plants.

PSO5: Students will be well versed with various mechanisms of GMOs and molecular techniques.

Course Outcomes

SEMESTER 1

BOT-H-CC 1-1: Plant Diversity

After successfully completing this course, students will be able to:

CO1: outline the distinguish between cryptogams and phanerogams.
CO2: Define general characters of cryptogams and Phanerogams.
CO3: Classify the members of plants groups in to cryptogams and Phanerogams.
CO4: Describe the Life cycle of plant forms of cryptogams and Phanerogams..
CO5: Discuss morphology of vegetative and reproductive parts of plants.

BOT-H -SEC1-1 MUSHROOM CULTIVATION

After successfully completing this course, students will be able to:

CO1: Mushroom biology-classification of mushrooms, edible mushrooms in India, poisonous mushrooms
CO2: know about Production of mushroom, bed preparation, ,culture media, pure culture of spawn, maintenance and preservation of pure culture,
CO3: know about the Research centres- National level and regional level, Cost-benefit ratio, Mushroom based Industry,
CO4: Mushroom market in India and abroad.

Practical Sem -I

After successfully completing this course, students will be able to:

CO1: Recognize the live forms of Cryptogamic and Phanerogamic plants.
CO2: Analyse and describe botanical concepts,
CO3: Illustrate the inflorescence, flower, floral parts, fruits and their types.
CO4: Preparation of culture media, pure culture, maintenance and preservation of pure culture , production of mushroom bed

SEMESTER 2

BOT-H-CC2-1: PLANT SYSTEMATICS

After successfully completing this course, students will be able to:

CO1: Define plant taxonomy and taxonomic related terminologies.
CO2: Explain classification systems of angiosperms.
CO3: Use required data sources for classification of angiosperms.
CO4: Determine Botanical Nomenclature of angiosperm plants.
CO5: Recognize ecological plant groups with examples.
CO6: Explain plant families with examples.
CO7: Apply proper herbarium methods - collecting, mounting, and keeping records.
CO8: Execute computer knowledge in plant taxonomy and digital herbarium.

BOT-H-SEC2-1: BIOFERTILIZERS

After successfully completing this course, students will be able to:

CO1: Green manuring and organic fertilizers; types and methods of composting, vermicompost and field applications.
CO2: Nitrogen fixing bacteria as biofertilizers:

CO3: Azolla and Anabaena azollae association, nitrogen fixation, factors affecting growth, blue green algae and Azolla
CO4: Isolation and inoculums production of VAM and its influence on growth and yield of crop plants.
CO5: features of potential biopesticides;
CO6: Baculovirus- characterization, bioformulation, mass production and field application.

Practical Sem -II

After successfully completing this course, students will be able to:

CO1: Define the botanical terms to identify the plant families.
CO2: Identify the plant families.
CO3: Draw the floral diagram of plants belonging to specific families.
CO4. Isolation of nitrogen fixing microbes to be used for biofertilizer production
CO5. Isolation and identification of soil fungi to be used as biopesticide activity
CO4: Identification of VAM associated with plants

SEMESTER 3

BOT-H-CC 3-1: ECONOMIC BOTANY

After successfully completing this course, students will be able to:

CO1: Define concept and scope of Pharmacognosy and economic botany.
CO2: Explain concept of Ayurvedic Pharmacy.
CO3: Discuss Ayurvedic principles and Ayurvedic formulation.
CO4: Recognize drug adulteration, methods of extraction and evaluation. CO5: Discuss the process of cultivation, collection and processing of herbal drugs. CO6: Recognize medicinally important drugs.
CO7: Explain principles and scope of ethnic societies in India.
CO8: Describe the methods in Analytical Medicinal botany.

BOT-H-CC 3-2: PLANT ANATOMY and EMBRYOLOGY

After successfully completing this course, students will be able to:

CO1: Define terms related to plant Anatomy, Embryology.
CO2: Describe various tissue systems in plants like epidermal, mechanical and vascular.
CO3: Interpret the Principles involved in distribution of mechanical tissues.
CO4: Explain the process of normal and abnormal secondary growth in plants.
CO5: Differentiate between normal and abnormal secondary growth.
CO6. Development of male and female gametophyte in angiosperm
CO7. Fertilization process in angiosperm, embryo and endosperm development

BOT-H-SEC-3-1 PLANT TISSUE CULTURE AND HORTICULTURE

After successfully completing this course, students will be able to:

CO1: know about the application of plant tissue culture,
CO2: Describe Plant Tissue Culture techniques.
CO3: Explain the concept and technique of Germplasm and Cryopreservation.
CO4. Utility of horticulture
CO5. Identification and uses of different horticulturally important flowers and fruits

Practical Sem -III

After successfully completing this course, students will be able to:

CO1: Study of anatomical details of both monocot and dicot root, stem and leaf
CO2: Study of anomalous secondary structure
CO3: Propagation of horticulturally important plants using different techniques
CO4: Media preparation, sterilization and aseptic inoculation of different plant explants

SEMESTER 4

BOT-H-CC 4-1: PHYCOLOGY

After successfully completing this course, students will be able to:

CO1: define algae on the basis of their cellular details.
CO2: classify algae according to their systems of classification.
CO3: recall the contribution of Indian phycologist.
CO4: explain the structure, reproduction and life cycle of Algae.
CO5: describe the development of different types reproductive structure.
CO6: diagram the life cycle of algal forms.
CO7: to know about uses and economics importance of algae.

BOT-H-CC 4-2: ARCHEGONIATE

After successfully completing this course, students will be able to:

CO1: Define Higher and Lower cryptogams.
CO2: Identify the vegetative and reproductive structures in Bryophytes and Pteridophytes.
CO3: Describe thallus organization of lower cryptogams.
CO4: Describe the Internal structure of the thallus of the lower cryptogams.
CO5: Diagram life cycle of various Bryophyte and Pteridophytic forms.
. CO6: Classify the higher cryptogams Pteridophytes and Gymnosperm
CO7. Know about the reproduction of different gymnosperm plants
CO8: Describe uses and economic importance and role of Cryptogams for human welfare.

BOT-H-CC 4-3: PALEOBOTANY and PALYNOLOGY

After successfully completing this course, students will be able to:

CO1: Memorize general characters of fossils of different era
CO2: Define fossil and fossil groups.
CO3: Classify different theories of angiospermic origin.
CO4: Summarize types and forms of fossils.
CO5. Study of pollen forms and their classification
CO6. Application of Palynology in different fields

BOT-H-CC 4-4: PARMACOLOGY AND ETHNO BOTANY

After successfully completing this course, students will be able to:

CO1: Define concept and scope of Pharmacognosy and economic botany.
CO2: Explain concept of Ayurvedic Pharmacy.
CO3: Discuss Ayurvedic principles and Ayurvedic formulation.
CO4: Recognize drug adulteration, methods of extraction and evaluation.
CO5: Discuss the process of cultivation, collection and processing of herbal drugs.
CO6: Recognize medicinally important drugs.
CO7: Explain principles and scope of ethnic societies in India.
CO8: Describe the methods in Analytical Medicinal botany.

Practical Sem –IV

After successfully completing this course, students will be able to:

CO1: Identify the different classes of the algae with reproductive structure
CO2: Identify and study on the vegetative and reproductive structures of Pteridophytes
CO3: Morphological study of different types of fossils.
CO4: Study of pollen types
CO5: Detection of pollen in different honey types
CO6: Histochemical tests of different medicinal plants
CO7: Powder microscopy
CO8: Determination of palisade ratio and vein-islet number for adulterated plant leaves uses in drug preparation

SEMESTER 5

BOT-H-CC 5-1: MYCOLOGY

After successfully completing this course, students will be able to:

CO1: Identify the vegetative and reproductive structures in fungi.
CO2: Describe thallus organization and reproductive structures of fungi.
CO3: Describe the Internal structure of the thallus of the fungi.
CO4: Diagram life cycle of various fungal genera
CO5: Classify the fungi, up to their class level.
CO6. Know about the fungal nutrition, physiology and secondary metabolite
CO7: Describe uses and economic importance and role of fungi for human welfare.

BOT-H-CC 5-2: MICROBIOLOGY

After successfully completing this course, students will be able to:

CO1:Know about bacterial classification, identifying characters for classification,
CO2: Concept of bacterial growth, differentiate among batch, fed batch, continuous and synchronous growth.
CO3. Know about the process of transformation, conjugation and transduction
CO4. Importance of Microbes in aspects, Industrial uses, medical uses
CO5: Discovery, physiochemical and biological characteristics of virus;
CO6: Know about Plant virus replication, disease transmission and control

BOT-H-CC 5-3: BIOCHEMISTRY

After successfully completing this course, students will be able to:

CO1: Define biochemical terms.

CO2: Explain Description and classification of biomolecules.
CO3. Study the different kinds of carbohydrates, proteins and lipids
CO4. Study of different types of secondary metabolite
CO4: use knowledge of the biomolecules from plant source in different applications

BOT-H-CC 5-4: CELL AND MOLECULAR BIOLOGY

After successfully completing this course, students will be able to:
CO1: Define terminologies related to cell and molecular biology.
CO2: Identify localization and describe all cell organelles.
CO3: Discuss the dynamics of plant cell structure and function.
CO4: Describe Nucleus and chromosomes.
CO5: Describe DNA replication, Transcription and Translation.
CO6: Explain the concepts as well as mechanisms of damage and repair.
CO7: Explain gene action and regulation (concept of operon, its structure and regulation).
CO8: Interpret the genomic organization and its role in gene expression

Practical Sem –V

After successfully completing this course, students will be able to undertake:
CO1: Basic Mycological Techniques Methods of sterilization, media preparation and culturing.
CO2: Identification and study of fungal vegetative and reproductive structures
CO3: Ethanol production.
CO4: Different isolation techniques of bacteria from soil, air / water.
CO5: Starch hydrolysis & Casein hydrolysis by bacteria
CO6: Detection of organic acids
CO7: Detection of carbohydrate and protein
CO8: Detection of the nature of carbohydrate
CO9: Estimation of DNA & RNA
CO 10. Counting of cells in a suspension, and measurement of cell

SEMESTER 6

BOT-H-CC 6-1: PHYTOPATHOLOGY

After successfully completing this course, students will be able to:
CO1: Define terminologies related plant diseases.
CO2: Discuss the plant and pathogen interaction.
CO3: Summarize the economic importance of plant diseases.
CO4: Explain principles and concepts of host-parasite interactions, systemic and acquired resistance and major signalling pathways.
CO5: Categorize the plant diseases on the basis of pathogen.
CO6: Evaluate the disease cycle of diseases caused by fungi, Bacteria, Nematode, viruses.
CO7: Apply wide spectrum control measures for plant diseases.
CO8: Justify molecular techniques to control the plant diseases.

BOT-H-CC 6-2: PLANT PHYSIOLOGY

After successfully completing this course, students will be able to:

CO1: Define the terminologies: Plant water relations, Growth, Transpiration, Ascent of Sap, Plant growth regulators and Nitrogen metabolism.
CO2: Explain processes of mineral nutrition, absorption of water, ascent of sap, mechanisms of water loss from plants.
CO3: Demonstrate processes imbibition, Osmosis, Diffusion and Plasmolysis, measure growth.
CO4: Describe Plant growth regulators and their types.
CO5: Discuss nitrogen metabolism in plants
CO6: Explain mechanisms and application of photoperiodism
CO7: Explain Mechanism of vernalisation.
CO8: Classify the plants based on Photoperiodism.

BOT-H-CC 6-3: GENETICS

After successfully completing this course, students will be able to:

CO1Differentiate between Pre Mendelian and Post Mendelian Concept in Genetics
CO2, Gene interaction and gene mapping
CO3. Chromosomal Aberration and numerical changes
CO4.Sex determination, pedigree analysis and extrachromosomal inheritance
CO5: Describe Eukaryotic DNA replication, Transcription and Translation.
CO6: Explain the concepts as well as mechanisms of damage and repair.
CO7: Explain gene action and regulation (concept of operon, its structure and regulation).
CO8: Interpret the genomic organization and its role in gene expression

Practical Sem -VI

After successfully completing this course, students will be able to undertake:

CO1: Isolation of the pathogen from diseased tissues.
CO2: Histopathology of Rust disease, and other plant diseases
CO3. Identification of different plant diseases
CO3: Relationship between transpiration and evaporation.
CO4: Determination of loss of water per stoma per hour.
CO5: Rate of imbibition of water by starchy, protein and fatty seeds
CO6: Chromosome preparation for microscopic study of mitotic and meiotic chromosomes
CO7. Study of different types abnormalities in meiotic and mitotic divisions
CO8: Basic knowledge of Bioinformatics

SEMESTER 7

BOT-H-CC7-1: PLANT GEOGRAPHY, ECOLOGY and EVOLUTION

After successfully completing this course, students will be able to:

CO1: describe the distribution of plants and their adaptive capacity in different area.
CO2: classify biomes and components.
CO3: demonstrate Endemism and EIA.
CO4: identify and describe various phytogeographical regions of India.
CO5. Study the Ecology of different places by Quadrat study
CO6. Distribution of Plants and their Evolutionary pattern

BOT-H-CC 7-2: PLANT BREEDING

After successfully completing this course, students will be able to:

CO 1: Define plant breeding, hybridization, Seeds, germination testing.
CO 2: Describe conventional techniques, methods and practices of breeding.
CO 3: Discuss mechanisms and genetic bases of resistance/tolerance to biotic and abiotic stresses in plants.
CO 4: Analyse general procedure of seed certification.
CO 5: Summarize the mechanisms of Seed sampling, storage and packaging.
CO 6: Explain the seed Testing and Seed marketing.
CO 7: Evaluate plant breeding methods for betterment of mankind and crop improvement.
CO 8: Interpret application of conventional and non-conventional methods of plant breeding.

BOT-H-CC 7-3: PLANT BIOTECHNOLGY

After successfully completing this course, students will be able to:

CO1: Study various steps in Recombinant DNA technology
CO2: Understand the role of enzymes and vectors in Recombinant DNA technology.
CO3: Report applications of genetic engineering in plants.
CO4. Different other techniques used in Biotechnology
CO5. Knowledge about the outcome of Different techniques used

BOT-H-CC 7-4: PLANT METABOLISM

After successfully completing this course, students will be able to:

CO1: define the importance of metabolites and their biosynthesis process.
CO2: explain the metabolism of plants and their application for mankind.
CO3: interpret the biochemical pathways in the plant.
CO4: discuss the metabolism of plant and their various activities.
CO5: Illustrate metabolic pool and biosynthesis of secondary metabolite.
CO6: Classify different photosynthetic pathways and their significance.
CO7: Determine factors affecting enzyme activity.
CO8: Calculate balance sheet of ATP.

BOT-H-CC 7-5: NATURAL RESOURCE MANAGEMENT

After successfully completing this course, students will be able to undertake:

CO1: Find interrelationship among different types of natural resources.
CO2: Management of forest resources: Agro-forestry, Social forestry, Farm forestry. Joint Forest Management, Forest policy of India
CO3: Wetland loss and degradation, Ramsar sites in India, Strategies for wetland conservation and management
CO4: Coal and minerals reserves and future, Renewable energy resources : Solar, wind, tidal, ocean, geothermal and Nuclear energy, Biomass gasification, Biofuel, Energy from wastes
CO6: livestock genetic resources biodiversity, sustainable livestock production, management of livestock
CO7: Employment and utilization of human as natural resources, Rural poverty and sustainable rural development, Human Development Index .

Practical Sem -VII

After successfully completing this course, students will be able to undertake:

CO1: Chromatography and measurement of Rf value
CO2: Measurement of oxygen uptake
CO3: Chloroplast extraction and assay
CO4: Community structure by quadrate method
CO5: Anatomical studies of leaves from polluted and less polluted
CO6: Emasculation and hybridization techniques
CO7: Estimation of Heterosis and Inbreeding depression
CO8.Study of an area by GPS method
CO9: Comparison of pH of soil of different sources, salinity, TDS in various types of water sample
CO10.Indirect Gene transfer technique
CO11. Protoplast Isolation
CO12. Plasmid Isolation
CO13. Isolation of Protein and Gel Electrophoresis

SEMESTER 8

BOT-H -CC-8- 1 : BIOSTATISTICS

After successfully completing this course, students will be able to understand :

CO1. Utility and limitations of biostatistics in plant research
CO2. Learn the sampling technique
CO3. Data representation in tabular as well as graphical form
CO4. Statistical analysis about central tendency and dispersion
CO5. Test of significance of different experimental results
CO6. Application of statistics in plant breeding experiments

BOT-H-CC 8-2: RESEARCH METHODOLOGY 1

After successfully completing this course, students will be able to:

CO1: define principles of botanical techniques.
CO2: discuss the concept of microscopy, chromatography, electrophoresis, spectroscopy, centrifuge, immunology and molecular biology.
CO3: illustrate applications of different types of microscopes, chromatography, spectrophotometers, centrifuges, pH meter and oxygen electrode.
CO4: analyses tissue/cell by histochemical and cytochemical techniques.
CO5: demonstrate TLC, ELISA, PCR and SDS-PAGE techniques.
CO6: determine radioactive techniques used in biology.
CO7: justify Immunological techniques.
CO8: relate electrochemical techniques in plant sciences.

BOT-H-CC 8-3: RESEARCH METHODOLOGY 2

After successfully completing this course, students will be able to:

CO1: interpret statistical analysis of the biological data.
CO2: recall basic principles behind the experimental design

CO3: explain testing of hypothesis.
CO4: prepare the experimental planning for laboratory work.
CO5: avail the conclusion w.r.t. biological data.
CO6: apply the computer based software for concluding the information gathered from biological source.
CO7: determine phylogenetic relationships using DNA and protein sequences.
CO8: analyze nucleotide sequence by molecular tools in proteins.

BOT-H-CC 8-4: STRESS BIOLOGY

After successfully completing this course, students will be able to:

CO1: Stress sensing mechanism in plants: calcium modulation, phospholipid signaling, concept of homeostasis
CO2: Pathogen recognition, Defence signalling molecules (PR proteins) and Role of phytohormones (SA, JA, ethylene) in stress signaling
CO3: biochemical adaptations understand accumulation of osmolytes, compatible solutes and antioxidant enzymes

BOT-H-CC8-5: INDUSTRIAL MICROBIOLOGY

After successfully completing this course, students will be able to:

CO1: Methods of immobilization, advantages and applications of immobilization, large scale application of immobilized enzymes
CO2: types of bioreactors- laboratory, pilot scale and production fermenters. Structure and applications of tower fermenter, fixed bed and fluidized bed bioreactors and air- lift Fermenter.
CO3: develop the industrial processes among the students.
CO4: Industrial waste production and management: management of waste from the industrial microbiology units: distillery, brewery, antiobiotic plants.

CO5: learn about Entrepreneurship and Management, and their application for establishment of Industry.

CO6: Differentiate usage of microbes for food, medicine, building materials, stimulating beverages.

Practical Sem -VIII

After successfully completing this course, students will be able to undertake:

CO1: Student's 't' test: Paired and unpaired
CO2: Test of Goodness of Fit
CO3: Determination of Coefficient of Correlation
CO4: Introduction to scientific reviews, types and importance.
CO7: Review writing, submission and presentation
CO4: Grant, funding and thrust area.
CO5: Quantitative estimation of Phenol & Proline content in the seedlings in the absence and presence of biotic/abiotic stress.
CO8: analyze nucleotide sequence by molecular tools in proteins.
CO9. Isolation of different industrially useful microbes from soil
CO10.How these isolated microbes gives the production