UNIVERSITY OF CALCUTTA

Notification No. CSR/43/2024

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 her powers under 9(6) of the said Act, the Vice-Chancellor has, by an order dated 10.07.2024 approved the syllabi for semester-3 & 4 of Botany for both 4-year Honours & Honours with Research and 3-year MDC courses of studies under CCF, 2022, which was introduced from the academic session 2023-2024.

The above shall take effect for Botany (4-year & 3-year) Courses of Studies under CCF which has been introduced from the academic Session 2023-2024.

19/7/2024

Prof.(Dr.) Debasis Das

Registrar

SENATE HOUSE

Kolkata-700073

19.07.2024

University Of Calcutta

Course Structure – 4 years Honours + Research (NEP 2020)

BOTANY SYLLABUS

(Semester III)

DSC/Core

ECONOMIC BOTANY (THEORY)

BOT-H-CC3-3-Th

(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:**

2.1 Cereals: Rice, Wheat, Jowar and Bajra (cultivation, processing and uses), Millets as future cereals. Origin of Rice and Wheat. 2.2 Pulses and Legumes: Cultivation and uses of Gram, Mung Bean and Soyabean. Importance to man and environment, 2.3 Oil and fats: General description, Classification, 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, 2.4 Rubber yielding plants: Para-rubber (*Hevea brasiliensis*), Assam rubber (*Ficus elastica*)- tapping, processing and uses, 2.5 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:**

3.1 Processing of sugarcane to products and byproducts. Extraction/ processing from Potato, Sugar beet and Palmyra palm. 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

4. Narcotics, timbers and fibres:

4.1 Habit forming drugs with special reference to Poppy, *Cannabis* and Tobacco (processing, uses and health hazards), 4.2 Timber: General account with special reference to Sal, Teak, Mahogany and Sissoo, 4.3 Fibers: Classification on the basis of origin of fibres, Cotton, Flax 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 (PRACTICAL)

BOT-H-CC3-3-P

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

1. **Identification (2× 9)** **18 marks**
2. **Practical notebook** **3 marks**
3. **Field notebook** **4 marks**

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

   Cereals: Rice and Wheat

   Legume: Gram, Mung bean and Soybean (habit, fruit and seed structure)

   Spices and condiments: Coriander, Cumin, Bay leaf, Black pepper, Cinnamon

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.Classroom performance: (lab records and field notebook)

4. Field visit to give an idea about cultivation of any one crop (viz. rice, jute, mustard, tea, potato)

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

Textbook 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.

University Of Calcutta

Course Structure – 4 years Honours + Research (NEP 2020)

BOTANY SYLLABUS

(Semester III)

DSC/Core

BOT-H-CC4-3-Th

PLANT ANATOMY & EMBRYOLOGY (THEORY)

(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 (PRACTICAL)

BOT-H-CC4-3-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**

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).

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.

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

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

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.

University Of Calcutta

Course Structure – 4 years Honours + Research (NEP 2020)

BOTANY SYLLABUS

(Semester III)

BOT-H-SEC-3-Th

PLANT TISSUE CULTURE AND HORTICULTURE PRACTICES (THEORY)

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

A. Plant Tissue Culture (50 marks)

1. **Plant Tissue Culture**: **3 Lectures**

1.1 Land mark contributions, 1.2 Importance of plant tissue culture as tools for fundamental and applied plant sciences, 1.3 Future prospects in improving cash crops, medicinal plants and forest trees.

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

2.1 Requirement of plant tissue culture laboratory- Equipment, instruments, glassware and plastic wares, 2.2 Aseptic technique- contaminants and sterilization, 2.3 Plant tissue culture medium: media preparation (basal medium), gelling agents and their uses, Use of plant growth regulators in plant tissue culture, 2.4 Cellular totipotency, 2.5 Organogenesis (direct and indirect), 2.6 Somatic embryogenesis and its significance, 2.7 Artificial seed (encapsulation and its potential uses).

3. **Types of culture techniques: 13 Lectures**

3.1 Plant micropropagation**:** Methods and advantages of micropropagation, Steps of general micropropagation, Important considerations and precautions, 3.2 Somaclonal variation: Types, applications of tissue culture-derived variation and crop improvement,3.3 Callus and haploid culture: Callus culture- Induction, maintenance and application, Suspension culture (introductory idea), 3.4 Haploid culture- Anther, pollen and ovary culture methods, application and utilization of haploids in agriculture 3.5 Protoplast culture- isolation and culture, protoplast

fusion (somatic hybridization), cybrid production, application, 3.6 Embryo and endosperm culture- procedure and application.

4. **Production of useful metabolites by tissue culture techniques:**

6 Lectures

4.1 Secondary metabolites: Techniques of production of secondary metabolites; terpenes, phenolics and alkaloids- definitions and functions, 4.2 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

1.1 Scope, importance and branches, 1.2 Role in rural economy and employment generation, 1.3 Harvesting and handling of fruits, vegetables and cut flower; methods of preservation and processing, 1.4 Urban horticulture and ecotourism.

2. Horticultural techniques: 3 Lectures

2.1 Application of manures, fertilizers, nutrients and PGRs, 2.2 Weed controls, biofertilizers, biopesticides, irrigation methods, 2.3 Hydroponics, propagation methods: vegetative (grafting, cutting, layering, budding), sexual (seed production), scope and limitations.

3. Ornamental plants: 5 Lectures

3.1 Types, classifications (annuals, perennials, climbers and trees), 3.2 Identification and salient features of 3.2.1 Some ornamental flowers (rose, marigold, gladiolus, carnations, rasna orchid, gerberas, tuberose, birds of paradise, pin cushion cactus and desert rose), 3.2.2 Ornamental flowering trees (Indian laburnum, gulmohar, jacaranda, jarul, fishtail palm, simul, coral tree), 3.2.3 Bonsai and their commercial use, 3.2.4 Importance of flower shows and exhibitions

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

4.1 Some common fruits and vegetables- description of plants and their economically important

parts (orange, banana, mango, papaya, guava, litchi, bael, potato, cauliflower, carrot, onion, peas, brinjal, ridged gourd), 4.2 Fruit processing- scope and benefit.

PLANT TISSUE CULTURE AND HORTICULTURE PRACTICES (PRACTICAL)

BOT-H-SEC-3-P

Total marks- 25; Credit 1, Class 30 hours

1. Work out/ Demonstration	**10 marks**
2. Identification (ornamental flowers)	**3 marks**
3. Field report & Diary	**5 marks**
4. Class room performance (Practical notebook)	**2 marks**
5. Viva-voce	**5 marks**

1. Field trip (any two with report submission) - Visit to plant tissue culture laboratory, gardens, standing crop sites, nurseries, vegetable plantations, horticultural fields at IARI/AHSI and cold storage.
2. Media preparation, sterilization and aseptic inoculation of explant for seed culture.
3. 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 and presented in a form of field diary during examination)
4. Identification of ornamental flowers as per theoretical 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. Collin, H.A. and Edwards, S. Plant Cell Culture, 1998, Bios Scientific Publishers

6. Dixon, R.A. & Gonzales, R. A. Plant Cell Culture: A Practical Approach, 1994, Oxford University Press

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

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

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

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

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

12. Singh, B.D. Biotechnology Latest ed., Kalyani Publishers.

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

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

15. Gupta, P.K. Biotechnology & Genomes, latest Ed., Rastogi Publications

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

17. Dey, K.K. Plant Tissue Culture, 1992, New Central Book Agency

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.

University Of Calcutta

Course Structure – 4 years Honours + Research (NEP 2020)

BOTANY SYLLABUS

(Semester IV)

DSC/Core

BOT-H-CC5-4-Th

PHYCOLOGY (THEORY)

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

PHYCOLOGY

1. General account :

1.1. Thallus organization and evolutionary trend in algal members of different groups, structure of algal cell, pigment types and variation, 1.2. Ultrastructure of flagella and chloroplast, 1.3. Process of reproduction in algae: Isogamy, Anisogamy, Oogamy- *Chlamydomonas*, *Oedogonium*, *Vaucheria*, Conjugation- *Spirogyra*, 1.5. Life cycle pattern in algae- Haplontic: *Chara*, Diplontic: *Fucus*, Haplo-diplontic (Isomorphic): *Ectocarpus*, Haplo-diplontic (Heteromorphic): *Laminaria*, Triphasic: *Polysiphonia*, 1.6. 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

2. Classification:

2.1. Classification by Lee (2018) upto phylum with examples, 2.2. Salient features of 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

3. Algal Ecology:

3.1. Role of phytoplanktons in aquatic ecosystem, 3.2. Algae in CO_2 sequestration, 3.3. Phytoremediation by algae

7 Lectures

4. Algal Biotechnology:

4.1. Algal culture and cultivation (Photobioreactor), 4.2. Algae as food, biofuel and biofertilizer

7 Lectures

PHYCOLOGY (PRACTICAL)

BOT-H-CC5-4-P

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

1. Work out: Algae **10 marks**

2. Identification with reasons: (Algae) **4 marks**

3. Classroom performance (Lab notebook, submission and permanent slides)
2+2+2=6 marks

4. Viva- voce **5 marks**

ALGAE

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.*

FIELD WORK

At least one local excursion to be conducted for study and collection of algae (only 5 from natural habitat).

CLASSROOM PERFORMANCE

1. Laboratory Note Book

2. Slides (permanent) prepared during practical classes.

3. Submission (5 algae collected from natural habitat and identified latter)

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

University Of Calcutta

Course Structure – 4 years Honours + Research (NEP 2020)

BOTANY SYLLABUS

(Semester IV)

DSC/Core

BOT-H-CC6-4-Th

ARCHAEGONIATES (THEORY)

(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**

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

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 2.4. *Gnetum*. **10 Lectures**
3. Pollination and Embryogeny of gymnosperms **2 Lectures**
4. Phylogeny: 4.1 Evolutionary significance of gymnosperms **2 Lectures**

ARCHAEGONIATES (PRACTICAL)

BOT-H-CC6-4-P

Total Marks 25; Credit 1, Class 30 hours

1.Workout on Pteridophytes 10 marks

2. Identification with reasons (Bryophytes, Pteridophytes and Gymnosperms) 6 marks

3.Classroom performance: (Lab records, slides) 2+2= 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.

University Of Calcutta

Course Structure – 4 years Honours + Research (NEP 2020)

BOTANY SYLLABUS

(Semester IV)

DSC/Core

BOT-H-CC7-4-Th

PALAEOBOTANY AND PALYNOLOGY (THEORY)

(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**

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, stratification 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, brief idea of basic tests for diagnosis– skin testing (Prick Test), Radioallergosorbent-Test (RAST) and Enzyme-Linked Immuno- Sorbent - Assay (ELISA), 7.5 Forensic palynology-definition, sources of pollen as forensic evidence– soil, clothing and foot wear, vehicles, human bodies, animal fur, spider web, 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; bee keeping.

12 lectures

PALAEOBOTANY AND PALYNOLOGY (PRACTICAL)

BOT-H-CC7-4-P

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

1. **Morphological study of mega fossils** **3 marks**
2. **Identification with reasons from permanent preparations (Anatomy + Pollen)** **3+3+3= 9 marks**
3. **Palynological study** **5 marks**
4. **Classroom performance: (Lab records)** **3 marks**
5. **Viva- voce** **5 marks**

PALAEOBOTANY AND PALYNOLOGY

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.

CLASSROOM PERFORMANCE

1. Laboratory note Book and report of each section must be signed by the respective teacher with date.

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.

University Of Calcutta

Course Structure – 4 year Honours + Research (NEP 2020)

BOTANY SYLLABUS

(Semester IV)

DSC/Core

BOT-H-CC8-4-Th

PHARMACOGNOSY & ETHNOBOTANY (THEORY)

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

1. **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.

4 lectures

2. **Pharmacognosy**- General account :

2.1 Pharmacognosy and its introduction and importance in modern medicine, 2.2 Crude drugs, 2.3 Classification of plant drugs- chemical and pharmacological action, 2.4 Drug evaluation– organoleptic, microscopic, chemical, physical and biological, 2.5. Major pharmacological groups of plant drugs and their uses, 2.6. Conservation of endangered and endemic medicinal plants.

8 lectures

3. **Secondary metabolites:**

3.1 Secondary metabolites and their differences with primary metabolites, 3.2 Interrelationship of basic metabolic pathways (Shikimate, Mevalonate, Acetate & MEP) with secondary metabolite biosynthesis (outlines only), 3.3 Major types and classification–terpenoids, phenolics, flavonoids, alkaloids and their pharmacological importance.

8 lectures

4. **Pharmacologically active constituents:**

Source plants (one example) parts used and uses of: 4.1 Steroids (Solasodin, Diosgenin, Digitoxin), 4.2 Tannin (Catechin), 4.3 Resins (Gingerol, Curcuminoids), 4.4 Alkaloids (Quinine, Atropine. Pilocarpine, Strychnine, Reserpine, Vinblastine, Taxol, Pyrolizidine), 4.5. Phenols (Sennoside and Capsaicin). **5 Lectures**

5. 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.

12 lectures

6. **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 (PRACTICAL)

BOT-H-CC8-4-P

Total Marks 25; Credit 1, Class 30 hours

1. **Workout (Items 1-4)** **5+6 = 11 marks**
2. **Identification of common medicinal plants from fresh specimen/ herbarium** **6 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.

University Of Calcutta

Course Structure – 3 year MDC (NEP 2020)

BOTANY SYLLABUS

(Semester III)

DSC/Core

ECONOMIC BOTANY (THEORY)

BOT-MD-CC3-3-Th

(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. Extraction/ processing from Potato and Sugar beet. 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 (PRACTICAL)

BOT-MD-CC3-3-P

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

1. **Identification (2× 9)** **18 marks**
2. **Practical notebook** **3 marks**
3. **Field notebook** **4 marks**

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

Cereals: Rice and Wheat

Legume: Gram, Mung bean and Soybean (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.Classroom performance: (lab records and field notebook)

3. Field visit to give an idea about cultivation of any one crop (viz. rice, jute, mustard, tea, potato)

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

TextbookReferences:

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.

University Of Calcutta

Course Structure – 3 year MDC (NEP 2020)

BOTANY SYLLABUS

(Semester IV)

DSC/Core

BOT-MD-CC4-4-Th

PHARMACOGNOSY & ETHNOBOTANY (THEORY)

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

7. 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.

4 lectures

8. Pharmacognosy- General account :

8.1 Pharmacognosy and its introduction and importance in modern medicine, 2.2 Crude drugs, 2.3 Classification of plant drugs- chemical and pharmacological action, 2.4 Drug evaluation– organoleptic, microscopic, chemical, physical and biological, 2.5. Major pharmacological groups of plant drugs and their uses, 2.6. Conservation of endangered and endemic medicinal plants.

12 lectures

9. Secondary metabolites:

9.1 Secondary metabolites and their differences with primary metabolites, 3.2 Interrelationship of basic metabolic pathways (Shikimate, Acetate, Mevalonate & MEP) with secondary metabolite biosynthesis (outlines only), 3.3 Major types and classification–terpenoids, phenolics, flavonoids, alkaloids and their pharmacological importance.

10 lectures

10. Pharmacologically active constituents:

Source plants (one example) parts used and uses of: 4.1 Steroids (Solasodin, Diosgenin, Digitoxin), 4.2

Tannin (Catechin), 4.3 Resins (Gingerol, Curcuminoids), 4.4 Alkaloids (Quinine, Atropine. Pilocarpine, Strychnine, Reserpine, Vinblastine, Taxol, Pyrolizidine), 4.5. Phenols (Sennoside and Capsaicin). **4 lectures**

11. 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 (PRACTICAL)

BOT-MD-CC4-4-P

Total Marks 25; Credit 1, Class 30 hours

1. **Workout (powder microscopy and histochemical tests) and chemical tests 5+6 = 11 marks**
2. **Identification of common medicinal plants from fresh specimen/ herbarium 6 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. 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.

University Of Calcutta

Course Structure – 3 year MDC (NEP 2020)

BOTANY SYLLABUS

(Semester IV)

DSC/Core

Plant Geography, Ecology and Evolution (THEORY)

BOT-MD-CC5-4-Th

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

PLANT GEOGRAPHY (15 marks)

1. Phytogeographical regions:

1.1Phytogeographical regions of India (Chatterjee 1960); 1.2. Dominant flora of Eastern Himalaya, Western Himalaya, Indian deserts and Sundarban.

5 lectures

2. **Endemism:**

2.1.Endemism types and Factors; 2.2. Age & Area hypothesis and Epibiotic theory; 2.3. Endemism in Indian flora.

4 lectures

ECOLOGY (30 marks)

1. **Preliminary idea on:**

1.1. Habitat and Niche (fundamental and realized), 1.2. Ecotone and Edge–effect, 1.3. Microclimate, 1.4. Ecads, Ecotypes and Ecoclines, 1.5. Carrying capacity.

3 lectures

2. **Community ecology:**

2.1. Community- Characteristics and diversity (α, β, γ), 2.2. Ecological succession –Primary and secondary, Seral stages (with reference to Lithosere and Hydrosere), autogenic and allogenic

succession, Climax community.

4 lectures

3.1. Plant indicators (metallophytes); 3.2. Phytoremediation.

3 lectures

4. **Conservation of Biodiversity:**

4.1. Level of Biodiversity: genetic, species & ecosystem diversity, 4.2. Biodiversity hot spots- criteria, Indian hotspots, 4.3. *In- situ* and *ex-situ* conservation, 4.4. Causes of extinction, 4.5. IUCN Red List categories, 4.6. Seed-banks, 4.7. Cryopreservation, 4.8. Geographic Information System and Remote Sensing (brief idea).

10 lectures

EVOLUTION (30 marks)

1.1 Introduction, 1.2. Theories of evolution: Evidences, Natural selection, Group selection, Neutral theory of molecular evolution, 1.3. Phyletic gradualism, Punctuated equilibrium and Stasis

6 lectures

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

6 lectures

3.1. Simplified phylogeny of bacteria, algae, fungi, bryophyte, pteridophyte and gymnosperm, 3.2. Phylogenetic tree.

4 lectures

PLANT GEOGRAPHY, ECOLOGY AND EVOLUTION (PRACTICAL)

BOT-MD-CC5-4-P

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

1.Work out on ecological parameters **10 marks**

2.Classroom performance: (lab records) **5 marks**

3. Field Records (Field note book of phytogeographical study and ecological study) **5 marks**

4. Viva-voce **5 marks**

PLANT GEOGRAPHY

1. Field visit- at least one long excursion at any phytogeographical region of India.
2. 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. Measurement of dissolved O_2 by azide modification of Winkler's method.
4. Determination of chemical properties of soil by rapid spot test (carbonate, iron, nitrate)
5. Estimation of organic carbon percentage present in soil sample.

Textbook References

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