CBCS SYLLABUS

FOR

THREE YEARS UNDER-GRADUATE COURSE

IN

BOTANY (HONOURS)

(*w.e.f. 2022-2023*)

BANKURA UNIVERSITY

BANKURA

WEST BENGAL

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CONTENTS

1. Introduction

The syllabus for Botany at undergraduate level using the Choice Based Credit system has been framed in compliance with model syllabus given by UGC. While framing the syllabus as per the UGC guideline, the topics have been kept as generic as possible as per our own infrastructure, expertise and strength.

The main objective of framing this new syllabus is to give the students a holistic understanding of the subject giving substantial weightage to both the core content and techniques used in Botany.

Keeping in mind and in tune with the changing nature of the subject, adequate emphasis has been given on new techniques and understanding of the subject.

The syllabus has also been framed in such a way that the basic skills of the subject are taught to the students, and everyone might not need to go for higher studies and the scope of securing a job after graduation will increase.

Considering the latest trends in the development of Plant Science and in compliance with the UGC model syllabus in Botany, some new topics in the fields of Disciplines specific elective courses as well as Skill enhancement courses like Research Methodology, Industrial and Environmental Microbiology, Bioinformatics, Agronomy, Stress Biology, Biofertilizers, Mushroom Culture Technology, Herbal Technology etc. have been included in the syllabus for the benefit of students from both theoretical and practical point of view.

1.1. Programme Outcome (PO)

PO	Summary	Description
PO 1	Sound Domain Knowledge	Students can acquire a strong, basic knowledge on origin, evolution and diversification in the basic and applied fields of Botany. They can develop relationship with the environments including their economic values.
PO 2	Laboratory Skill	The syllabus has the aim to develop good laboratory skills with latest advanced tools, sophisticated instruments and modern technologies to address emerging problems with scientific viewpoint.
PO 3	Overall Skill	Students will able to think logically and scientifically into structural outline, gather appropriate knowledge and skill for future career, planning and conducting independent project proposal and make appropriate report on it.

PO 4	Team Work	The syllabus will enhance the development of the spirit of team work; learn to harbor collaborative approach to explore new facts and facets of the subject.
PO 5	Academic and Scientific Endeavour	Students will gain cognitive development, innovative approach, technical maneuvering, entrepreneurship and managerial skills to set up a new start-up.
PO 6	Eco-friendly Approach	The course has a futuristic approach to develop eco-friendly management practices to make socio-economic upliftment.
PO 7	Ethical Awareness	Development of ethical awareness among students regarding research & publications is another outcome of the proposes course.
PO 8	Goal of life	The syllabus will help to inculcate visions in students so that they can play a vital role for the advancement of the discipline in the greater benefits of the society.

1.2. Programme Specific Outcome (PSO)

PSO	Summary	Description
PSO 1	Rational analysis	Development of fundamental concepts, rational thinking & analytical skill.
PSO 2	Skill Development	Development of skill in some area like mushroom culture technology, Nursery & Gardening, Biofertilizer, Vermicomposting etc.
PSO 3	Soft Skill Proficiency	Development of communication skill, attitudes, leadership quality, ethical values and social awareness.
PSO 4	Ethical Awareness	Development of i) concept on ethical principles of education and research, i i) responsibility on environment and iii) knowledge of norms of the biodiversity conservation.
PSO 5	Environmental Consciousness	Increase in eco-friendly consciousness, waste-management practices to overcome environmental pollution and degradation of environment.
PSO 6	Hygiene Practices	Builds up good habit of hygienic practices.
PSO 7	Scientific Attitude	Inculcation of i) research mind and approach to develop eco-friendly products and ii) knowledge of basic sciences, life sciences and fundamental process of plants to study and analyze any related fact.
PSO 8	Resource Management	Development of knowledge & skill on natural & renewable resource management.

PSO 9	Dry-lab Practices	Development of ability of sequence analysis & structure prediction.
PSO 10	Awareness against Infectious Diseases	Development of awareness against infectious & fatal diseases.
PSO 11	Ecological Awareness	Understanding the valuable impact of the plant diversity in social and environmental aspects and demonstrate the knowledge and need of sustainable development.
PSO 12	Skill Development	Students will gain knowledge through different Hands-on-training program on agro-economic activities.
PSO 13	Social Interaction	Development of community link up through regular survey on Health & Nutritional parameters, Ethno-veterinary interests of local villagers.
PSO 14	Ethno-medicinal Practices	Development of knowledge on Ethno-medicinal Plants, their commercial usage & worldwide applications.
PSO 15	Compatible Agricultural	Development of concept about significance of crop improvement through genetic engineering in the present context of growing population.

2. Scheme for CBCS Curriculum

2.1. Credit Distribution across Courses

Course Type	Total Papers	Credits	
		Theory + Practical	Theory*
Core Courses	14	14×4= 56 14×2= 28	14×5= 70 14×1= 14
Discipline Specific Electives	4	4×4= 16 4×2= 8	4×5= 20 4×1= 4
Generic Electives	4	4×4= 16 4×2= 8	4×5= 20 4×1= 4
Ability Enhancement Language Courses/ ENVS	2	1×2= 2 (ENG / MIL) 1×4= 4 (ENVS)	1×2= 2 (ENG / MIL) 1×4= 4 (ENVS)
Skill Enhancement Courses	2	2×2= 4	2×2= 4
Totals	**26**	**142**	**142**

*Tutorials of 1 Credit will be conducted in case of no practical component

2.2. Scheme for CBCS Curriculum in Botany (Honours)

SEMESTER- I

Course Code	Course Title	Credit	Marks			No. of Hours/Week		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
SH/BOT/101/ C-1	Archegoniate & Palaeobotany (Theory & Practical)	6 (T4+P2)	10	40 (T25+P15)	50	4	N.A.	4
SH/BOT/102/ C-2	Mycology & Phytopathology (Theory & Practical)	6 (T4+P2)	10	40 (T25+P15)	50	4	N.A	4
SH/BOT/103/ GE-1	Plant Biodiversity [Microbes, Algae, Fungi, Archegoniate] (For students of other discipline)	6 (T4+P2)	10	40 (T25+ 15)	50	4	N.A.	4
ACSHP/104/ AECC-1	Environmental Studies	4	10	40	50	4	N.A	N.A
	Total in Semester - I	**22**	**40**	**160**	**200**			

N.B. Theory: 1 Credit= 1 Hour/Week, Practical: 1 Credit= 2 Hours/Week, Tutorial: 1 Credit= 1 Hour/Week

SEMESTER- II

Course Code	Course Title	Credit	Marks			No. of Hours/Week		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
SH/BOT/201/ C-3	Phycology & Microbiology (Theory & Practical)	6 (T4+P2)	10	40 (T25+P15)	50	4	N.A.	4
SH/BOT/202/ C-4	Biomolecules & Cell Biology (Theory & Practical)	6 (T4+P2)	10	40 (T25+P15)	50	4	N.A.	4
SH/BOT/203/ GE-2	Any one from: (Theory & Practical) 1. Genetics & Plant Breeding 2. Plant Anatomy & Embryology (For students of other discipline)	6 (T4+P2)	10	40 (T25+P15)	50	4	N.A.	4
ACSHP/204/ AECC-2	English/Hindi/MIL/Communicative English	2	10	40	50	2	N.A	N.A
	Total in Semester - II	**20**	**40**	**160**	**200**			

N.B. Theory: 1 Credit= 1Hour/Week, Practical: 1 Credit= 2 Hours/Week, Tutorial: 1 Credit= 1 Hour/Week

SEMESTER –III

Course Code	Course Title	Credit	Marks			No. of Hours/Week		
			I.A.	ESE	Total	Lec	Tu.	Pr.
SH/BOT/301/ C-5	Morphology & Anatomy of Angiosperms (Theory & Practical)	6 (T4+P2)	10	40 (T25+P15)	50	4	N.A	4
SH/BOT/302/ C-6	Plant Systematics (Theory & Practical)	6 (T4+P2)	10	40 (T25+P15)	50	4	N.A	4
SH/BOT/303/ C-7	Genetics & Plant Breeding (Theory & Practical)	6 (T4+P2)	10	40 (T25+P15)	50	4	N.A	4
SH/BOT/304/ GE-3	Any one from: (Theory & Practical) 1. Plant Ecology, Morphology & Taxonomy 2. Cell and Molecular Biology (For students of other discipline)	6 (T4+P2)	10	40 (T25+P15)	50	4	N.A	4
SH/BOT/305/ SEC-1	Any one from: 1. Biofertilizers 2. Herbal Technology	2(T)	10	40	50	2	N.A	N.A
	Total in Semester - III	**26**	**50**	**200**	**250**			

N.B. Theory: 1 Credit= 1 Hour/Week, Practical: 1Credit= 2 Hours/Week, Tutorial: 1 Credit= 1 Hour/Week

SEMESTER –IV

Course Code	Course Title	Credit	Marks			No. of Hours/Week		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
SH/BOT/401/ C-8	Molecular Biology (Theory & Practical)	6 (T4+P2)	10	40 (T25+P15)	50	4	N.A	4
SH/BOT/402/ C-9	Plant Ecology & Phytogeography (Theory & Practical)	6 (T4+P2)	10	40 (T25+P15)	50	4	N.A	4
SH/BOT/403/ C-10	Economic Botany & Pharmacognosy (Theory & Practical)	6 (T4+P2)	10	40 (T25+P15)	50	4	N.A	4
SH/BOT/404/ GE-4	Any one from: (Theory & Practical) 1. Plant Physiology & Metabolism 2. Economic Botany & Plant Biotechnology (For students of other discipline)	6 (T4+P2)	10	40 (T25+P15)	50	4	N.A	4
SH/BOT/405/ SEC-2	Any one from: 1. Mushroom Culture Technology 2. Medicinal Botany	2(T)	10	40	50	2	N.A.	N.A.
	Total in Semester - IV	**26**	**50**	**200**	**250**			

N.B. Theory: 1Credit= 1 Hour/Week, Practical: 1 Credit= 2 Hours/Week, Tutorial: 1 Credit= 1Hour/Week

SEMESTER – V

Course Code	Course Title	Credit	Marks			No. of Hours / Week		
			I.A.	ESE	Total			
SH/BOT/501/ C-11	Reproductive Biology of Angiosperms (Theory & Practical)	6 (T4+P2)	10	40 (T25+P15)	50	4	N.A	4
SH/BOT/502/ C-12	Plant Physiology (Theory & Practical)	6 (T4+P2)	10	40 (T25+P15)	50	4	N.A	4
SH/BOT/503/ DSE-1	Any one from: (Theory & Practical) 1. Natural Resource Management 2. Horticultural Practices & Post Harvest Technology	6 (T4+P2)	10	40 (T25+P15)	50	4	N.A	4
SH/BOT/504/ DSE-2	Any one from: (Theory & Practical) 1. Agronomy 2. Stress Biology	6	10	40	50	4	N.A	4
Total in Semester – V		**24**	**40**	**160**	**200**			

N.B. Theory:- 1 Credit= 1 hour/Week, Practical:- 1 Credit= 2 hours/Week, Tutorial:- 1 Credit= 1 hour/Week

SEMESTER – VI

Course Code	Course Title	Credit	Marks			No. of Hours / Week		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
SH/BOT/601/ C-13	Plant Metabolism (Theory & Practical)	6 (T4+P2)	10	40 (T25+P15)	50	4	N.A	4
SH/BOT/602/ C-14	Plant Biotechnology (Theory & Practical)	6 (T4+P2)	10	40 (T25+P15)	50	4	N.A	4
SH/BOT/603/ DSE-3	Any one from: (Theory & Practical) 1.Industrial & Environmental Microbiology 2. Bioinformatics	6 (T4+P2)	10	40 (T25+P15)	50	4	N.A	4
SH/BOT/604/ DSE-4	Any one from: (Theory & Practical) 1. Analytical Techniques in Plant sciences 2. Research Methodology	6 (T4+P2)	10	40 (T25+P15)	50	4	N.A	4
Total in Semester – VI		**24**	**40**	**160**	**200**			

N.B. Theory: 1 Credit= 1 Hour/Week, Practical: 1 Credit= 2 Hours/Week, Tutorial: 1 Credit= 1 Hour/Week

[SC= Subject Code, C= Core Course, AECC= Ability Enhancement Compulsory Course, SEC= Skill Enhancement Course, GE= Generic Elective, DSE= Discipline Specific Elective IA= Internal Assessment, ESE= End-Semester Examination, Lec.=Lecture, Tu.= Tutorial, and Pr.=Practical]

2.3. Choices for Discipline Specific Electives

SEMESTER	COURSE	CHOICE
SEM-V	DSE-1	Any one from: 1. Natural Resource Management 2. Horticultural Practices & Post Harvest Technology
	DSE-2	Any one from: 3. Agronomy 4. Stress Biology
SEM-VI	DSE-3	Any one from: 5. Industrial & Environmental Microbiology 6. Bioinformatics
	DSE-4	Any one from: 7. Analytical Techniques in Plant Sciences 8. Research Methodology

2.4. Choices of Skill Enhancement Courses

SEMESTER	COURSE	CHOICE
SEM-III	SEC-1	Any one from: 1. Biofertilizers 2. Herbal Technology
SEM-IV	SEC-2	Any one from: 3. Mushroom Culture Technology 4. Medicinal Botany

2.5. Choices for Generic Elective Courses

SEMESTER	COURSE	CHOICE
SEM-I	GE-1	1. Plant Biodiversity [Microbes, Algae, Fungi, Archegoniate]
SEM-II	GE-2	Any one from: 2. Genetics and Plant Breeding 3. Plant Anatomy & Embryology
SEM-III	GE-3	Any one from: 4. Plant Ecology, Morphology & Taxonomy 5. Cell and Molecular Biology
SEM-IV	GE-4	Any one from: 6. Plant Physiology & Metabolism 7. Economic Botany & Plant Biotechnology

2.6. Question Pattern

Core and DSE papers

Theory (F.M: 25)		Practical (F.M: 15)
UNIT-I		1. Work out/Demonstration/Experiment and/or Identification: **10/9**
1. Any five out of eight	**1×5= 5**	
UNIT-II		2. Laboratory Record and/or Field record: **2/3**
2. Any two out of four	**5×2= 10**	
UNIT-III		3. Viva Voce: **3**
3. Any one out of two	**10×1= 10**	

SEC papers

Theory (F.M: 40)	
UNIT-I	
1. Any five out of eight	**2×5= 10**
UNIT-II	
2. Any four out of six	**5×4= 20**
UNIT-III	
3. Any one out of two	**10×1= 10**

3. Core Courses

Semester- I

3.1. Core T1: Archegoniate and Palaeobotany
Course Code: SH/BOT/101/C-1

(Theory: Lectures 60/Credits 4/Marks 25)

Course Learning Outcomes:

- Understanding of archegoniatae- Bryophytes, Pteridophytes and Gymnosperms.
- Understanding on morphology, anatomy and reproduction of Bryophytes, Pteridophytes and Gymnosperms.
- Understanding of plant evolution and their transition to land habitat.
- Demonstration of proficiency in the experimental techniques and methods of appropriate analysis of Bryophytes, Pteridophytes, Gymnosperms.
- Understanding of plant evolution through time.

Unit 1: Introduction (4 lectures)
Unifying features of archegoniates; Alternation of generations and concept of sporophyte and gametophyte.

Unit 2: Bryophytes (6 lectures)
General characteristics; Adaptations to land habit; Classification; Range of thallus organization. Economic Importance.

Unit 3: Type Studies- Bryophytes (12 lectures)
Classification (Proskauer-1957), morphology, anatomy and reproduction of *Riccia, Marchantia, Anthoceros and Funaria* (developmental stages not included); Evolutionary trends among the genus (developmental stages not included).

Unit 4: Pteridophytes (6 lectures)
General characteristics; Classification; Early land plants (*Cooksonia* and *Rhynia*; Vegetative and reproductive organography of *Lepidodendron* and *Calamites*).

Unit 5: Type Studies- Pteridophytes (14 lectures)
Classification (Outline of Pichi Sermolli, 1977), Morphology, anatomy and reproduction of *Selaginella*, *Equisetum* and *Pteris* (Developmental details not to be included). Apogamy and apospory, heterospory, telome theory, stelar evolution; Ecological and economic importance.

Unit 6: Gymnosperms (14 lectures)
General characteristics, classification- Stewart & Rothwell (1993), morphology, anatomy and reproduction of *Cycas*, *Pinus* and *Gnetum* (Developmental details not to be included); Ecological and economic importance, General account of Progymnospermopsida, *Glossopteris* plant, *Lyginopteris* plant and *Williamsonia* plant.

Unit 7: Palaeobotany (4 Lectures)
Fossils-Definition, Types of Fossils, Importance of fossils, Fossilization Processes, Geological Time-Scale and Megafloral succession.

3.1. Core P1: Archegoniate and Palaeobotany

(Practical: Marks 15/Credits 2)

1. ***Marchantia***- Vertical section of thallus through gemma cup, whole mount of gemmae; Vertical section of antheridiophore, archegoniophore; Longitudinal section of sporophyte.

2. ***Anthoceros***- Vertical section of thallus; T.S. and L.S. of sporophyte.

3. ***Funaria***- Antheridial and archegonial heads from permanent slides; Longitudinal section of capsule.

4. ***Selaginella***- Transverse section of stem; Longitudinal section of strobilus.

5. ***Equisetum***- Morphology, transverse section of internode; Longitudinal section of strobilus, transverse section of strobilus.

6. ***Pteris***- Morphology; Transverse section of rachis; Vertical section of sporophyll; Whole mount of sporangium; Whole mount of spores.

7. ***Cycas***- Whole mount of microsporophyll; Transverse section of rachis; Vertical section of leaflet; Whole mount of spores; Longitudinal section of ovule (from permanent slides).

8. ***Pinus***- Transverse section of Needle; Transverse section of stem; Longitudinal section of/ transverse section of male cone (from permanent slides).

9. **Identification-**Petrified fossil (*Calamites* and *Lyginopteris*), Impression fossil (*Glossopteris*).

10. Botanical excursions are to be organized in botanically rich area, field report and photographic documents of plant specimens to be submitted during practical examination (No need to submit any living, preserved or herbarium specimen).

Suggested Readings

1. Vashistha, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta. S. Chand. Delhi, India.
2. Bhatnagar, S.P. & Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.
3. Parihar, N.S. (1991). An introduction to Embryophyta: Vol. I. Bryophyta. Central Book Depot. Allahabad.
4. Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGraw Hill, Delhi.
5. Vanderpoorten, A. & Goffinet, B. (2009). Introduction to Bryophytes. Cambridge University Press.
6. Stewart W.N., Rothwell, G.W. (2005). Paleobotany and the Evolution of Plants, 2nd Edition, Cambridge University Press (USA).

3.2 Core T2: Mycology and Phytopathology
Course Code: SH/BOT/102/C-2

(Theory: Lectures 60/Credits 4/Marks 25)

Course Learning Outcomes:

- Developing the knowledge on fungi and basic concept on common plant diseases.
- Practice of skill development in laboratory and field work related to mycology and plant pathology.
- Understanding the knowledge of allied groups of fungi and lichens and the approach of their utilizations in applied fields.

Unit 1: Introduction to fungi (4 lectures)

General characteristics; Affinities with plants and animals; Thallus organization; Cell wall composition and cell organization; Nutrition; Classification (Ainsworth, 1973).

Unit 2: Chytridiomycota and Zygomycota (5 lectures)

Characteristic features; Ecology and significance; Thallus organization; Reproduction; Life cycle with reference to *Synchytrium, Rhizopus.*

Unit 3: Oomycota (4 lectures)

General characteristics; Ecology; Life cycle and classification with reference to *Phytophthora, Albugo.*

Unit 4: Ascomycota (10 lectures)

General characteristics (asexual and sexual fruiting bodies); Ecology; Life cycle; Heterokaryosis; Life cycle and classification with reference to *Saccharomyces, Ascobolus.*

Unit 5: Basidiomycota (8 lectures)

General characteristics; Reproduction; Ecology; Life cycle of *Lycoperdon* and *Agaricus*; Bioluminescence, fairy rings.

Unit 6: Deuteromycota (3 lectures)
General accounts, conidial morphology, conidiomata and parasexual cycle; Study of *Alternaria* and *Fusarium*.

Unit 7: Allied Fungi (2 lectures)
General characteristics; Status of slime molds, occurrence, types of plasmodia, types of fruiting bodies.

Unit 8: Symbiotic associations (4 lectures)
Lichen – occurrence, general characteristics, growth, forms and range of thallus organization, Nature of associations of algal and fungal partners, reproduction, importance; Mycorrhiza-ectomycorrhiza, endomycorrhiza and their significance.

Unit 9: Applied Mycology (10 Lectures)
Role of fungi in biotechnology; Application of fungi in food industry (flavour & texture, fermentation, baking, organic acids, enzymes, mycoproteins); Secondary metabolites (pharmaceutical preparations); agriculture (biofertilizers); biological control (mycofungicides, mycoherbicides, mycoinsecticides, myconematicides); Mycotoxins; Medical mycology.

Unit 10: Phytopathology (10 lectures)
Terms and concepts; Koch's postulates; general symptoms; geographical distribution of diseases; Etiology; host-pathogen relationships; disease cycle and environmental relation (disease triangle); Management of plant diseases, and role of quarantine; bacterial diseases – citrus canker and bacterial blight of rice; Viral diseases – tobacco mosaic disease; Fungal diseases – late blight of potato, black stem rust of wheat, white rust of crucifer, brown spot of rice.

3.2. Core P2: Mycology and Phytopathology

(Practical: Marks 15/Credits 2)

Mycology

1. ***Rhizopus*:** study of asexual stage from temporary mounts and sexual structures through permanent slides.
2. ***Albugo*:** Study of symptoms of plants infected with *Albugo*; Asexual phase study through section/temporary mounts and sexual structures through permanent slides.
3. ***Ascobolus*:** Sectioning through ascocarp.
4. ***Puccinia*:** Herbarium specimens of black stem rust of wheat and infected barberry leaves; sections/ mounts of spores on wheat and permanent slides of both the hosts.

5. ***Agaricus*:** Specimens of button stage and full grown mushroom; sectioning of gills of *Agaricus*.

Phytopathology

1. **Phytopathology:** Herbarium specimens of bacterial diseases: Citrus Canker; Viral diseases: TMV, Fungal diseases: Late blight of potato, black stem rust of wheat, brown spot of rice and white rust of crucifers.

Suggested Readings

1. Agrios, G.N. (1997). Plant Pathology, 4th edition, Academic Press, U.K.
2. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley & Sons (Asia) Singapore. 4th edition.
3. Webster, J. and Weber, R. (2007). Introduction to Fungi, Cambridge University Press,Cambridge. 3rd edition.
4. Deacon, J.W. (2013). Fungal Biology, 4th edition, John Wiley &Sons Ltd.
5. Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, Macmillan Publishers India Ltd.
6. Sharma, P.D. (2011). Plant Pathology, Rastogi Publication, Meerut, India
7. H. C. L. Gwynne-Vaugham and B. Barnes (2014). Fungi: Their Structure and Development,Biotech Books.
8. Gopinath Hait. 2016. A Text Book of Mycology, New Central Book Agency (P) Ltd.
9. R. S. Mehrotra and A. Aggarwal. 2010. Plant Pathology (Second Edition), Tata Mc Graw Hill Education Pvt. Ltd.

Semester-II

3.3. Core T3: Phycology and Microbiology

Course Code: SH/BOT/201/C-3

(Theory: Credits 4/ Lectures 60/Marks 25)

Course Learning outcomes:

- Developing the concept of microbes and Algae: classification and types.
- Understanding viruses - their characteristics and structures.
- Understanding the facts regarding diseases and awareness.
- Examining the general characteristics of bacteria and their cell reproduction/Recombination.
- Characteristics of algae and their reproduction.
- Increasing the concept of utilization of viruses bacteria and algae in human welfare.
- Conduct practical experiments using skills appropriate to the study of the microbes and algae.

Phycology (15 Marks)

Unit 1: Algae (11 lectures)
Introduction and general characteristics; Ecology and distribution; Range of thallus organization; cell structure and components; Cell wall, pigment system, reserve food (of only groups represented in the syllabus), flagella; Methods of reproduction; Classification, criteria, system of Fritsch, and evolutionary classification of Lee, 2008 (outline); Significant contributions of important phycologists (F.E. Fritsch, G.M. Smith, R.N. Singh, T.V. Desikachary, H.D. Kumar, M.O.P.Iyengar); Role of algae in the environment, agriculture, biotechnology and industry

Unit 2: Cyanophyta, Xanthophyta and Bacillariophyta (8 lectures)
Ecology and occurrence; Range of thallus organization; Cell structure; Reproduction, Morphology and asexual reproduction of *Nostoc*, *Zygnema*; Morphology and life-cycle of *Vaucheria,* Cell structure and auxospore formation in Diatoms.

Unit 3: Chlorophyta and Charophyta (8 lectures)
General characteristics; Occurrence; Range of thallus organization; Cell structure; Reproduction. Morphology and life-cycles of *Chlamydomonas*, *Oedogonium*, *Chara*; Evolutionary significance of *Prochloron.*

Unit 4: Phaeophyta and Rhodophyta (10 lectures)
Characteristics; Occurrence; Range of thallus organization; Cell structure; Reproduction. Morphology and life-cycles of *Ectocarpus*, *Fucus* and *Polysiphonia.*

Microbiology (10 marks)

Unit 5: Introduction to Microbial world (6 lectures)

Types of microbes; Economic importance of bacteria and viruses with reference to vaccine production, role in research, medicine and diagnostics, as causal organisms of diseases, role in agriculture and industries

Unit 6: Viruses (6 lectures)
Discovery; Physiochemical and biological characteristics; Classification (Baltimore); General structure with special reference to viroids and prions; Replication (general account); DNA virus (T-phage), lytic and lysogenic cycle; RNA virus (TMV).

Unit 7: Bacteria (11 lectures)
Discovery; general characteristics; Principles and modern approaches of bacterial taxonomy, brief outline classification of domain bacteria, Types - archaebacteria, eubacteria, wall-less forms (mycoplasma and spheroplasts); Cell structure; Nutrition and nutritional types; Growth and metabolism; Reproduction- vegetative, asexual; Recombination (conjugation, transformation and transduction).

3.3. Core P3: Phycology and Microbiology

(Practical: Credits 2/15 Marks)

Phycology (08 marks)

Study of vegetative and reproductive structures of *Nostoc, Zygnema, Oedogonium, Chara.* Study of vegetative and reproductive structures of *Fucus and Polysiphonia* (from permanent slides).

Microbiology (07 marks)

1. Electron micrographs/Models of viruses – T2-Phage and TMV, line drawings/ photographs of lytic and lysogenic cycle.
2. Types of bacteria to be observed from temporary/permanent slides/photographs. Electron micrographs of bacteria, binary fission, endospore, conjugation, root nodule.
3. Gram staining and simple staining of bacteria.
4. Endospore staining with malachite green (endospores taken from soil bacteria).
5. Study of microorganisms from curd sample by simple staining process.

Suggested Readings

1. Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.
2. Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 9th Edition. McGraw Hill International.
3. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.
4. Sahoo, D. (2000). Farming the ocean: seaweeds cultivation and utilization. Aravali International, New Delhi.
5. Campbell, N.A., Reece J.B., Urry L.A., Cain M.L., Wasserman S.A. Minorsky P.V., Jackson R.B. (2008). Biology, Pearson Benjamin Cummings, USA. 8th edition.
6. Pelczar, M.J. (2001) Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.
7. Sandikar, B.M.(2021). Fundamental Microbiology, Books & Allied (P) Ltd., Kolkata.
8. Sen, K., Giri, P. (2022). Fundamental Botany: Microbiology, Phycology & Lichenology, Santra publication pvt. Ltd. Kolkata.
9. Mishra, B.K., Dash, N. (2022). Microbiology and Phycology, Kalyani publishers, Delhi.

3.4. Core T4: Biomolecules and Cell Biology
Course Code: SH/BOT/202/C-4

(Theory: Lectures 60/Credits- 4/Marks 25)

Course Learning Outcomes:

- Understanding the basic concept of cell biology.
- This course gives a vast knowledge about cell and its different bio molecules and structure and functions of biomolecules.
- Important information about bioenergetics, enzyme which are really important for the living world.
- A concept about cell organelles, cell cycle, cell division and multiplications.
- Gather knowledge about the biochemical analysis of different biomolecules, Chromosome study, different physical processes involved in cell.

Biomolecules (12 Marks)

Unit 1: Biomolecules (20 lectures)

Types and significance of chemical bonds; Structure and properties of water; pH and buffers. **Carbohydrates:** Nomenclature and classification; Monosaccharides; Disaccharides; Oligosaccharides and polysaccharides.

Lipids: Definition and major classes of storage and structural lipids; Fatty acids structure and functions; Essential fatty acids; Triacyl glycerols structure, functions and properties; Phosphoglycerides.

Proteins: Structure of amino acids; Levels of protein structure-primary, secondary, tertiary and quaternary; Protein denaturation and biological roles of proteins.

Nucleic acids: Structure of nitrogenous bases; Structure and function of nucleotides; Types of nucleic acids; Structure of A, B, Z types of DNA; Types of RNA; Structure of tRNA.

Unit 2: Bioenergenetics (4 lectures)

Laws of thermodynamics, Concept of free energy, Endergonic and exergonic reactions, Coupled reactions, Redox reactions. ATP: structure, its role as an energy currency molecule.

Unit 3: Enzymes (6 lectures)

Structure of enzyme: holoenzyme, apoenzyme, cofactors, coenzymes and prosthetic group; Classification of enzymes; Mechanism of action (activation energy, lock and key hypothesis, induced - fit theory), Michaelis – Menten equation, enzyme inhibition and factors affecting enzyme activity.

Cell Biology (13 Marks)

Unit 4: The cell (4 lectures)
Cell as a unit of structure and function; Characteristics of prokaryotic and eukaryotic cells; Origin of eukaryotic cell (Endosymbiotic theory).

Unit 5: Cell wall and plasma membrane (4 lectures)
Chemistry, structure and function of plant cell wall; Overview of membrane function; fluid mosaic model; Chemical composition of membranes; Membrane transport – Passive, active and facilitated transport, endocytosis and exocytosis.

Unit 6: Cell organelles (16 lectures)
Nucleus: Structure-nuclear envelope, nuclear pore complex, nuclear lamina, molecular organization of chromatin; nucleolus.
Cytoskeleton: Role and structure of microtubules, microfilaments and intermediary filament.
Chloroplast, mitochondria and peroxisomes: Structural organization; Function; Semiautonomous nature of mitochondria and chloroplast.
Endomembrane system: Endoplasmic Reticulum – Structure, targeting and insertion of proteins in the ER, protein folding, processing; Smooth ER and lipid synthesis; Export of proteins and lipids; Golgi Apparatus – organization, protein glycosylation, protein sorting and export from Golgi Apparatus; Lysosomes

Unit 7: Cell division (6 lectures)
Phases of eukaryotic cell cycle, mitosis and meiosis; Regulation of cell cycle- checkpoints, role of protein kinases.

3.4. Core P4: Biomolecules and Cell Biology

(Practical: Marks 15/Credits 2)

(Biomolecules- 07 marks & Cell Biology- 08 Marks)

1. Qualitative tests for carbohydrates, reducing sugars, non-reducing sugars, lipids and proteins.
2. Study of plant cell structure with the help of epidermal peel mount of Onion/*Rhoeo*.
3. Demonstration of the phenomenon of protoplasmic streaming in *Hydrilla* leaf.
4. Measurement of cell size by the technique of micrometry.
5. Study of the phenomenon of plasmolysis and deplasmolysis.
6. Study of different stages of mitosis (from root tip of *Allium cepa*) and meiosis (from flower buds of *Allium cepa*).

Suggested Readings

1. Campbell, MK (2012) Biochemistry, 7th ed., Published by Cengage Learning.
2. Campbell, PN and Smith AD (2011) Biochemistry Illustrated, 4th ed., Published by Churchill Livingstone.
3. Tymoczko JL, Berg JM and Stryer L (2012) Biochemistry: A short course, 2nd ed., W.H.Freeman.
4. Berg JM, Tymoczko JL and Stryer L (2011) Biochemistry, W.H.Freeman and Company.
5. Nelson DL and Cox MM (2008) Lehninger Principles of Biochemistry, 5th Edition., W.H. Freeman and Company.
6. Karp, G. (2010). Cell Biology, John Wiley & Sons, U.S.A. 6th edition.
7. Hardin, J., Becker, G., Skliensmith, L.J. (2012). Becker's World of the Cell, Pearson Education, Inc. U.S.A. 8th edition.
8. Cooper, G.M. and Hausman, R.E. (2009) The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
9. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009) The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.
10. Sahu, A.C. (2022) Biomolecules and Cell Biology. Kalyani Publishers, New Delhi.

Semester-III

3.5. CoreT5: Morphology & Anatomy of Angiosperms
Course Code: SH/BOT/301/C-5

(Theory: Lecture 60/Credits 4/Marks 25)

Course Learning Outcomes:

- Study the external structure of plants for identification of the plant
- Know about different plants organ like root, stem and leaves and their importance.
- Learn about various plants parts, embryonic development, breeding activity and conservation techniques.
- Develop an understanding of concepts and fundamentals of plant anatomy.
- Examine the internal anatomy of plant systems and organs.
- Develop critical understanding on the evolution of concept of organization of shoot and root apex.
- Analyze the composition of different parts of plants and their relationships.
- Evaluate the adaptive and protective systems of plants.
- Generating in students an interest in plant structure and wood for having a wise approach in timber use, one of the most economically useful resources.

Morphology (09 Marks)

Unit 1: Root (2 Lectures)
Types and modifications.

Unit 2: Stem (2 Lectures)
Types and modifications.

Unit 3: Leaf (4 Lectures)
Type of leaves; Phyllotaxy; Modifications of leaves, Stipules and their modifications.

Unit 4: Inflorescence and Flower (**8 Lectures**)
Inflorescence types and evolution; Types of flower; Flower as a modified shoot; Aestivation; Adhesion and cohesion of floral parts; Placentation and its evolution; Floral formula, floral diagram.

Unit 5: Fruits, dispersal of fruits and seeds (5 Lectures)
Definition and types of fruit; Dispersal mechanisms of fruits and seeds.

Anatomy (16 Marks)

Unit 4: Structure and Development of Plant Body (5 Lectures)
Internal organization of plant body:; Types of cells and tissues; Three tissue systems, General idea of mechanical tissues and its distribution.

Unit 5: Tissues (8 Lectures)
Classification of tissues; Simple and complex tissues (no phylogeny); Cytodifferentiation of tracheary elements and sieve elements; Pits and plasmodesmata; Ergastic substances. Hydathodes, cavities, lithocysts and laticifers.

Unit 6: Apical meristems (10 Lectures)
Evolution of concept of organization of shoot apex (Apical cell theory, Histogen theory, Tunica Corpus theory); Types of vascular bundles; Structure of dicot and monocot stem; structure of dicot and monocot leaf, Kranz anatomy; Organization of root apex (Apical cell theory, Histogen theory, Korper-Kappe theory); Quiescent centre; Root cap; Structure of dicot and monocot root; Root stem transition.

Unit 7: Vascular Cambium and Wood (10 Lectures)
Structure, function and seasonal activity of cambium; Secondary growth in root and stem. Sapwood and heartwood; Ring and diffuse porous wood; Early and late wood, tyloses. Development and composition of periderm, rhytidome and lenticels. Anomalous secondary growth in stems (*Bignonia*, *Boerhaavia*, *Strychnos* & *Dracaena*).

Unit 8: Adaptive and Protective Systems (6 Lectures)
Epidermal tissue system, cuticle, epicuticular waxes, trichomes (uni-and multicellular, glandular and nonglandular, two examples of each), stomata (classification); Anatomical adaptations of xerophytes and hydrophytes.

3.5. Core P5: Morphology &Anatomy of Angiosperms

(Practical: Marks 15/Credits 2)

Morphology: (05 Marks)

1. Identification with reasons: Types of leaves, stipules, tendril, inflorescence, fruits, calyx, corolla, androecium, gynoecium.

2. Dissection and display of: i. Flower of *Canna indica*, ii. Hypanthodium inflorescence of *Ficus glomerata/ Ficus hispida*, iii. Spikelet inflorescence of *Oryza sativa*, iv. Fruits of *Citrus acida*.

Anatomy (10 Marks)

2. T.S. of monocot and dicot root
3. T.S. of monocot and dicot stem.
4. T.S. of isobilateral and dorsiventral leaves.
5. Anomalous secondary structures of *Bignonia*, *Strychnos*, *Boerhaavia* & *Dracaena* stem
6. Microscopic Identification: Xylem: Tracheary elements -tracheids, vessel elements; xylem fibres.
   Phloem: Sieve tubes-sieve plates; companion cells; phloem fibres.
   Epidermal system: stomata types; trichomes: non-glandular and glandular.
   Secretory tissues: cavities, lithocysts and laticifers.
7. Tissue maceration

Suggested Readings

Morphology

1. Naik, V. N. Taxonomy of Angiosperms. Tata Mc. Graw Hill Publishers Co. 1981. New Delhi.
2. Sachdeva, S. K. 1990. Angiosperms, Morphology, Anatomy, Taxonomy, Evolution. Kalyani Publishers, New Delhi.
3. Plant Systematics. Gurucharan Singh. 2005 (2nd Edition). Oxford & IBH.
4. Plant Taxonomy- Nair. Tata Mc. Graw Hill Publisher Company Limited.

Anatomy

1. Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Fahn, A. (1974). Plant Anatomy. Pergmon Press, USA.
3. Mauseth, J.D. (1988). Plant Anatomy. The Benjammin/Cummings Publisher, USA.
4. Evert, R.F. (2006) Esau's Plant Anatomy: Meristems, Cells, and Tissues of the Plant Body: Their Structure, Function and Development. John Wiley and Sons, Inc.

3.6. Core T6: Plant Systematics
Course Code: SH/BOT/302/C-6

(Theory: Lecture 60/Credits 4/Marks 25)

Course Learning Outcomes:

- Knowledge about appropriate method of identification of plants to contribute classification to trace the evolution and interpretation among the plants.
- Understanding the principles of general taxonomy and nomenclatural rules.
- Explanation of concept of species.
- Development of the concept to classify plants
- Recognition of the importance of herbarium, virtual herbarium and botanic garden.
- Interpretation the rules of ICN in botanical nomenclature.
- Assessment of terms and concepts related to phylogenetic systematics.

Unit 1: Significance of Plant Systematics (10 lectures)
Introduction to systematics; Plant identification, Classification, Nomenclature. Evidences from palynology, cytology, phytochemistry. Functions of Herbarium; Important herbaria and botanical gardens of the world and India; Virtual herbarium; E-flora; Documentation: Flora, Monographs, Journals; Phases of taxonomy.

Unit 2: Taxonomic hierarchy (4 lectures)
Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary).

Unit 3: Botanical nomenclature (8 lectures)
Principles and rules (ICN); Ranks and names; Typification, author citation, effective and valid publication, rejection of names, principle of priority and its limitations.

Unit 4: Systems of classification (10 lectures)
Types of angiospermic plant classification, Broad outline, relative merits and demerits of major systems of classifications – Bentham and Hooker, and Cronquist (1988). Brief reference of Angiosperm Phylogeny Group (APG III) classification.

Unit 5: Biometrics, numerical taxonomy and cladistics (8 lectures)
Characters; Variations; OTUs, character weighting and coding; Cluster analysis; Phenograms, cladograms (definitions and differences).

Unit 6: Phylogeny of Angiosperms (10 lectures)
Terms and concepts (primitive and advanced taxa, homology and analogy, parallelism and convergence, monophyly, Paraphyly, polyphyly and clades). Origin and evolution of angiosperms.

Unit 7: **Salient features of the following families** [Evolutionary trends need to be briefly discussed in case of families marked with asterisks] (10 Lectures)

Dicotyledons: Magnoliaceae*, Malvaceae, Brassicaceae, Fabaceae, Euphorbiaceae, Apiaceae, Apocynaceae, Asclepiadaceae, Solanaceae, Scrophulariaceae, Lamiaceae, Verbenaceae, Acanthaceae, Rubiaceae, Cucurbitaceae, Asteraceae*.

Monocotyledons: Alismataceae*, Poaceae, Musaceae, Orchidaceae*.

3.6 Core P6: Plant Systematics

(Practical: Marks 15/Credits 2)

1. Study of vegetative and floral characters of the following families (Description, V.S. flower, Section of ovary, floral diagrams, floral formula/e and identification upto the genus following any published keys.

Families: Malvaceae, Fabaceae, Apocynaceae, Asclepiadaceae Asteraceae, Solanaceae, Scrophulariaceae, Lamiaceae, Verbenaceae, Acanthaceae, Rubiaceae, Cucurbitaceae, Euphorbiaceous.

2. **Field visits** (local and at least one distal)- Excursion/Field trips are to be organized in botanically rich areas. A field report with photographic document of plants (at least 20) and corresponding field record to be submitted during practical examination.

3. Submission of a properly dried and pressed herbarium specimen of any one wild plant.

Suggested Readings

1. College Botany Vol. III. New Central Book Agency. Calcutta.
2. Sharma, O.P. 2009. Plant Taxonomy. Mc Graw Hill Education Pvt. Ltd., India.
3. Pandey, H.P. 2010. Principles of Plant Systematics: With special reference to Current Trends in Plant Taxonomy, Lambert Academic Publishing.
4. Pandey, A.K., Khasana, S. 2021. Plant Systematics, 1st edition, CRC Press.
5. Simpson, M.G. 2019. Plant Systematics, 3rd edition, Elsevier.
6. Datta, S. C. 1991. Systematic Botany. Wiley Eastern Ltd. New Delhi, Calcutta.
7. Judd, Campbell, Kellogg. Stevens. 2003. Phylogeny & Evolution of Vascular Plants. Sinaurer Associates Inc. Publishers Sunderland. Massachusetts. USA.
8. Lawrence, G. H. M. 1981. Taxonomy of Vascular Plants. Mc Milian New York.
9. Naik, V. N. Taxonomy of Angiosperms. Tata Mc. Graw Hill Publishers Co. 1981. New Delhi
10. Plant Groups. (Recent Edition). H. Mukherjee. New Central Book Agency.
11. Plant Systematics. Gurucharan Singh. 2005 (2nd Edition). Oxford & IBH.
12. Plant Systematics. Simpson. 2006. Elsivier. 11. S. K. Mukherjee. 1984.
13. Sachdeva, S. K. 1990. Angiosperms, Morphology, Anatomy, Taxonomy, Evolution. Kalyani Publishers, New Delhi.

14. Sporne, K. R. 1974. The Morphology of Angiosperms: The structure and evolution of flowering plants. Hutchinson University Library. London.
15. Takhtajan, A. 2009. Flowering Plants, Springer.
16. Takhtajan, A. 1986. Diversity & Plant Distribution. Oliver & Boyd.
17. Jeffrey, C. (1982). An Introduction to *Plant Taxonomy*. Cambridge University Press, Cambridge.
18. Radford, A.E. (1986). Fundamentals of *Plant Systematics*. Harper and Row, New York.

3.7. Core T7: Genetics and Plant Breeding
Course code: SH/BOT/303/C-7

(Theory: Lecture 60/Credits 4/Marks 25)

Course Learning Outcomes:

- Development of detail knowledge about Mendelian and non-Mendelian genetics with several practical approaches.
- Development of concept about the nucleic acids & how nucleic acids transport genetic information among offspring.
- Understanding scientific cause behind several abnormal chromosomal syndromes.
- Understanding basic causes of gene mutation its detection & DNA-repair mechanism.
- Knowledge about the different crop plants
- Knowledge about the different breeding equipments.
- Understanding the relation between crops and human beings and how much plant breeding is necessary for our growing population.
- Development of knowledge on plant breeding to apply in crop development.

Genetics (15 Marks)

Unit 1: Mendelian genetics and its extension (10 lectures)
Mendelism: History; Principles of inheritance; Chromosome theory of inheritance; Autosomes and sex chromosomes; Incomplete dominance and codominance; Multiple alleles (ABO blood groups & Rh-alleles), Lethal alleles, Epistasis (Dominant & Recessive), Polygenic inheritance (Kernel colour in wheat & ear size in maize).

Unit 2: Extrachromosomal Inheritance (6 lectures)
Chloroplast inheritance in *Mirabilis jalapa* plant; Mitochondrial inheritance in yeast; Maternal effects-shell coiling in snail; Infective heredity- Kappa particles in *Paramecium*.

Unit 3: Linkage, crossing over (8 lectures)
Linkage and crossing over-Cytological basis of crossing over; Recombination frequency, two Factor and three factor crosses.

Unit 4: Variation in chromosome number and structure (8 lectures)
Deletion, Duplication, Inversion, Translocation, Euploidy and Aneuploidy

Unit 5: Gene mutations (6 lectures)
Types of mutations; Molecular basis of Mutations; Mutagens – physical and chemical (UV-ray, X-ray, Base analogs, deaminating, alkylating and intercalating agents); Role of Transposons in mutation, DNA repair mechanisms.

Plant Breeding (10 Marks)

Unit 6: Introduction to Plant Breeding (4 lectures)
Objectives. Breeding systems: modes of reproduction in crop plants. Important achievements and undesirable consequences of plant breeding.

Unit 7: Methods of crop improvement (10 lectures)
Introduction: Centres of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self pollinated, cross pollinated and vegetatively propagated plants; Hybridization: For self, cross and vegetatively propagated plants – Procedure, advantages and limitations.

Unit 8: Inbreeding depression and heterosis (4 lectures)
History, genetic basis of inbreeding depression and heterosis; Applications.

Unit 9: Crop improvement and breeding (4 lectures)
Role of mutations; Polyploidy; Distant hybridization and role of biotechnology in crop improvement.

3.7. Core P7: Genetics and Plant Breeding

(Practical: Marks 15/Credits 2)

1. Testing of goodness of fit with Mendelian monohybrid and dihybrid ratios.
2. Incomplete dominance and gene interaction through seed ratios (9:7, 12:3:1).
3. Study of aneuploidy through photograph: Down's, Klinefelter's and Turner's syndromes.
4. Photographs/Permanent Slides showing Translocation Ring, Laggards and Inversion Bridge.
5. Hybridization techniques - Emasculation, Bagging (For demonstration only).
6. Induction of polyploidy conditions in plants (For demonstration only).

Suggested Readings

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (1991). Principles of Genetics, John Wiley & sons, India. 8th edition.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics, John Wiley & Sons Inc., India. 5th edition.
3. Russel, P.J. (2016), iGenetics: A molecular Approach, 3rd edition, Pearson Education (US).
4. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings, U.S.A. 9th edition.
5. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.
6. Ajoy, Pal. Text Book of Genetics – from Genes to Genomes, Books and Allied (P) Ltd., Kolkata.
7. Singh, B. D.-Plant Breeding, Kalyani Publishers.
8. Vijendradas L. D.; Plant Breeding. New Age International (p).

Semester-IV

3.8. Core T8: Molecular Biology
Corse Code: SH/BOT/401/C-8

(Theory: Lecture 60/Credits 4/Marks 25)

Course Learning Outcome:

- Studies of the structures and chemical properties of DNA and RNA to develop practical concept.
- Study of replication of DNA and Transcription of RNA will be studied to prepare the concept of central dogma – an essential lively process to control life.
- Acquiring the molecular concept of protein synthesis and related cellular reactions and the basic knowledge of instrumentation to study these reactions will be acquired.

Unit 1: Nucleic acids: Carriers of genetic information (4 lectures)
Historical perspective; Nucleic Acids as the carrier of genetic information (DNA -Griffith's, Hershey & Chase; RNA -Fraenkel-Conrat's experiment).

Unit 2: The Structures of DNA and RNA (10 lectures)
DNA Structure: Salient features of double helix, Types of DNA, Types of genetic material, denaturation and renaturation, cot curves; RNA Structure, Organelle DNA- mitochondria and chloroplast DNA. The Nucleosome Chromatin structure, Euchromatin, Heterochromatin-Constitutive and Facultative heterochromatin.

Unit 3: The replication of DNA (10 lectures)
General principles – bidirectional, semi-conservative and semi discontinuous replication, RNA priming; Various models of DNA replication: Rolling circle, θ (theta) mode of replication, replication of linear ds-DNA, Enzymes involved in DNA replication.

Unit 4: Central dogma and genetic code (2 lectures)
Key experiments establishing-The Central Dogma (Adaptor hypothesis and discovery of mRNA template), Genetic code (deciphering & salient features).

Unit 5: Transcription (18 lectures)
Transcription in prokaryotes. Principles of transcriptional regulation; Prokaryotes: Regulation of lactose metabolism and tryptophan synthesis in *E.coli*. Gene silencing.

Unit 6: Processing and modification of RNA (8 lectures)
Split genes-concept of introns and exons, removal of introns, spliceosome machinery, splicing pathways, group I and group II intron splicing, alternative splicing eukaryotic mRNA processing (5' cap, 3' polyA tail); Ribozymes.

Unit 7: Translation (8 lectures)
Ribosome structure and assembly, mRNA; Charging of tRNA, aminoacyl tRNA synthetases; Various steps in protein synthesis: Initiation, elongation and termination of polypeptides in prokaryotes; Inhibitors of protein synthesis; Post-translational modifications of proteins.

3.8. Core P8: Molecular Biology

(Marks 15/Credits 2)

1. Preparation of LB medium and raising *E.coli*.
2. Demonstration of isolation of genomic DNA from *E.coli*.
3. DNA estimation by diphenylamine reagent/UV Spectrophotometry.
4. Study of DNA replication mechanisms through photographs (Rolling circle, heta replication and semi-discontinuous replication).
5. Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs.
6. Photographs establishing nucleic acid as genetic material (Messelson and Stahl's, Avery et al, Griffith's, Hershey & Chase's and Fraenkel & Conrat's experiments)
7. Study of the following through photographs: Assembly of Spliceosome machinery; Splicing mechanism.

Suggested Readings

1. Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology of the Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons Inc., U.S.A. 5th edition.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. Benjamin Cummings. U.S.A. 9th edition.
4. Russell, P. J. (2010). i-Genetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3rd edition.
5. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to GeneticAnalysis. W. H. Freeman and Co., U.S.A. 10th edition.
6. Ajoy, Pal. Text Book of Cell and Molecular Biology, Books And Allied (P) Ltd., Kolkata.

3.9. Core T9: Plant Ecology & Phytogeography
Course Code: SH/BOT/402/C-9

(Theory: Lecture 60 /Credits 4/Marks 25)

Course Learning Outcomes:

- Development of concept on global ecological issues.
- Acquiring knowledge about ecosystems and biodiversity.
- Knowledge about the distribution of plants and there arrangement - both natural and manmade are studied for having a total view to relate the distribution pattern of plants to establish more sustainable plant community systems in the world.
- Understanding core concepts of biotic and abiotic environments.
- Knowledge about soils - physical, chemical and biological components.
- Analysis of the phytogeography or phytogeographical division of India.
- Evaluation of energy sources of ecological system.
- Acquiring the concept of adaptation of plants in relation to light, temperature, water, wind and fire.
- Development of skills for ecological practices.

Unit 1: Introduction (4 lectures)

Basic concepts; Levels of organization. Inter-relationships between the living world and the environment, the components and dynamism, homeostasis.

Unit 2: Soil (6 lectures)

Importance; Origin; Formation; Composition; Physical; Chemical and Biological components; Soil profile; Role of climate in soil development.

Unit 3: Water (4 lectures)
Importance: States of water in the environment; Atmospheric moisture; Precipitation types (rain, fog, snow, hail, dew); Hydrological cycle; Water in soil; Water table.

Unit 4: Light, temperature, wind and fire (6 lectures)
Variations; adaptations of plants to their variation.

Unit 5: Biotic interactions (4 lectures)
Trophic organization, basic source of energy, autotrophy, heterotrophy; symbiosis, commensalism, parasitism; food chains and webs; ecological pyramids; biomass, standing crop.

Unit 6: Population ecology (4 lectures)
Characteristics and Dynamics .Ecological Speciation

Unit 7: Plant communities (8 lectures)
Concept of ecological amplitude; Habitat and niche; Characters: analytical and synthetic; Ecotone and edge effect; Dynamics: succession – processes, types; climax concepts.

Unit 8: Functional aspects of ecosystem (12 lectures)
Structural and functional components of ecosystem. Principles and models of energy flow; Production and productivity; Ecological efficiencies; Biogeochemical cycles; Cycling of Carbon, Nitrogen and Phosphorus.

Unit 9: Phytogeography (12 lectures)
Principles and objectives of phytogeography; Endemism, theories of endemism,types of endemic species; Brief description of major terrestrial and aquatic biomes; Phytogeographical regions of India;

3.9. Core P9: Plant Ecology and Phytogeography

(Practical: Marks 15/Credits 2)

1. Determination of pH of various soil and water samples (by pH meter and pH paper).
2. Determination of nutrient content of soil by kit-method.
3. Determination of dissolved oxygen of water samples from polluted and unpolluted sources.
4. Ecological (anatomical) adaptations of some species: *Ipomoea aquatica* stem, Phyllode of *Acaccia auriculiformis*, *Nerium* leaf and *Vanda* root.
5. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus.
6. Determination of frequency, density and abundance of herbaceous species found in the College premises..
7. Field visits to familiarize students with ecosystem of different sites.

Suggested Readings

1. Ambasht, R. S. A Text book of plant ecology. Students Friends Co. Varanasi.
2. Dash, M. C. Fundamentals of Ecology. Tata Mc. Graw Hil Publishing Company Ltd.
3. Good, R. Plant Geography. Oxford & IBH.
4. Kormondy, B. J. 1983. Concept of Ecology (Recent edition) Prentice Hall India Ltd. New Delhi.
5. Kuman, H. D. Modern Concept of ecology. Vikas Publications House New Delhi
6. Odum, E. P. fundamentals of Ecology (recent edition) W. B. Sunders & Co. Philadelphia.
7. Plant Ecology. R. Mishra. Oxford & IBH.
8. Sharma, P. D. Geology and Environment (10^{th} edition). Rastogi Publications. Meerut.
9. Sharma, p. D. Environmental Biology and Toxxicology (10th edition) Rastogi Publications. Meerut. Odum, E. P. Ecology. Hoit Reinhart and Winston Inc.
10. Treatise on Plant Ecology. K. N. Bhatia and k. K. Sharma. (Recent edition) Pradeep Publications Jalaandhar.
11. Wilkinson, D.M. (2007). Fundamental Processes in Ecology: An Earth Systems Approach. Oxford University Press. U.S.A.

3.10. Core T10: Economic Botany and Pharmacognosy
Course Code: SH/BOT/403/C-10

(Theory: Lecture 60/Credits 4/Marks 25)

Course Learning Outcomes:

- Learn the relationship between plant and people. This paper intersects many fields such as agronomy, chemistry, anthropology, economy ethnobotany, geography, forestry, horticulture.
- Understand core concepts of Economic Botany and relate with environment, populations, communities, and ecosystems.
- Develop critical understanding on the evolution of concept of organization of apex new crops/varieties, importance of germplasm diversity, issues related to access and ownership.
- Develop a basic knowledge of taxonomic diversity and important families of useful plants
- Increase the awareness and appreciation of plants & plant products encountered in everyday life.
- Appreciate the diversity of plants and the plant products in human use.
- To know about medicinal properties and uses of plants by folklore and ayurveda system. Ability of conserve rare and threatened plant species both in in-vivo and in-vitro conditions.

Economic Botany (15 marks)

Unit 1: Origin of Cultivated Plants (6 lectures)

Concept of Centres of Origin, their importance with reference to Vavilov's work. Examples of major plant introductions; Crop domestication and loss of genetic diversity; evolution of newcrops/varieties, importance of germplasm diversity.

Unit 2: Cereals (6 lectures)
Wheat and Rice (origin, morphology, processing & uses); Brief account of millets.

Unit 3: Legumes (6 lectures)
Origin, morphology and uses of Chick pea, Pigeon pea and fodder legumes. Importance to man and ecosystem.

Unit 4: Sources of sugars and starches (4 lectures)
Morphology and processing of sugarcane, products and by-products of sugarcane industry. Potato – morphology, propagation & uses.

Unit 5: Spices (6 lectures)
Listing of important spices, their family and part used. Economic importance with special reference to fennel, saffron, clove and black pepper.

Unit 6: Beverages (4 lectures)
Tea, Coffee (morphology, processing & uses)

Unit 7: Sources of oils and fats (10 lectures)
General description, classification, extraction, their uses and health implications groundnut, linseed, soybean, mustard and coconut (Botanical name, family & uses). Essential Oils: General account, extraction methods, comparison with fatty oils & their uses.

Unit 8: Natural Rubber (3 lectures)
Para-rubber: tapping, processing and uses.

Unit 9: Timber plants (3 Lectures)
General account with special reference to teak and pine.

Unit 10: Fibres (4 lectures)
Classification based on the origin of fibres; Cotton, Coir and Jute (morphology, extraction and uses).

Pharmacognosy (10 marks)

Unit 11: 9 (10 Lectures)
Definition and history of pharmacognosy, its comparision with pharmacology and pharmacy. Drugs – crude and commercial; preperation of drugs for commercial market; organoleptic, microscopic and physical evaluation of drugs; drug constituents and adulteration.

Unit 12: Drug-yielding plants: (5 Lectures)
Therapeutic and habit-forming drugs with special reference to *Cinchona* spp., *Rauwolfia serpentina, Strychnos* sp, *Justicia adhatoda.*

3.10 Core P10: Economic Botany and Pharmacognosy

(Practical: Marks 15/Credits 2)

Economic Botany:

1. **Cereal**: Rice (habit sketch, study of paddy and grain, starch grains, micro-chemical tests).
2. **Legume**: Groundnut, (habit sketch, fruit, seed structure, micro-chemical tests).
3. **Source of sugar**: Sugarcane (habit sketch; cane juice- micro-chemical tests).
4. **Source of oil**: Mustard–plant specimen, tests for oil in crushed seeds.
5. **Fibre-yielding plant**: Cotton (specimen, whole mount of seed to show lint and fuzz; whole Mount of fiber and test for cellulose).

Pharmacognosy:

6. **Drug-yielding plants**: Organoleptic and microscopic studies of *Strychnos* seed, *Justicia adhatoda* leaf, Ginger rhizome.
7. Phytochemical test for identification of alkaloids, tannins and terpenes.

Suggested Readings

1. Kochhar, S.L. (2012). Economic Botany in Tropics, MacMillan & Co. New Delhi, India.
2. Wickens, G.E. (2001). Economic Botany: Principles & Practices. Kluwer Academic Publishers, The Netherlands.
3. Chrispeels, M.J. and Sadava, D.E. 1994 Plants, Genes and Agriculture. Jones & Bartlett Publishers.
4. Bhattacharya, K., Ghosh, A.K., Hait, G. (2017). A Textbook of Botany, Vol-IV, New Central Book Agency (P) Ltd.
5. Mahammad Ali.(2010). Text Book of Pharmacognosy. CBS publishers.
6. Tayler, V. E. 1988. Pharmacognosy.

Semester-V

3.11. Core T11: Reproductive Biology of Angiosperms
Course Code: SH/BOT/501/C-11

(Theory: Lecture 60/Credits 4/Marks 25)

Course Learning Outcomes:

- The students will be able to understand different reproductive parts of angiosperm and their functions. They also study about different kind of pollen grain, their structure and functions and also their effects on animals.
- Palynology involved in plant identification.
- Important to learn about various plants parts, embryonic development, breeding activity and conservation techniques.
- Recall the history of reproductive biology of angiosperms & recognize the importance of genetic and molecular aspects of flower development
- Evaluate and understand structure and functions of different reproductive structures. v) the special structures of
- Solve Self-incompatibility in Pollination and fertilization.

Unit 1: Introduction and History of palynology (4 lectures)

Unit 2: Reproductive development (6 lectures)

Induction of flowering; Flower development: Genetic and molecular aspects.

Unit 3: Anther and pollen biology (10 lectures)

Anther wall: Structure and functions, microsporogenesis, callose deposition and its significance. Microgametogenesis; Pollen wall structure, MGU (male germ unit) structure, Pollen aperture and ornamentation, NPC system;Palynology and scope (a brief account); Pollen viability, storage and germination; Abnormal features: Pseudomonads, polyads, massulae, pollinia.

Unit 4: Ovule (10 lectures)

Structure; Types; Special structures–endothelium, obturator, aril, caruncle and hypostase; Female gametophyte– megasporogenesis (monosporic, bisporic and tetrasporic) and megagametogenesis (*Polygonum* type); Organization and ultrastructure of mature embryo sac.

Unit 5: Pollination and fertilization (6 lectures)

Pollination types and significance; adaptations; structure of stigma and style; path of pollen tube in pistil; double fertilization.

Unit 6: Self incompatibility (10 lectures)

Basic concepts (interspecific, intraspecific, homomorphic, heteromorphic, GSI and SSI); Methods to overcome self- incompatibility: mixed pollination, bud pollination, stub pollination; Intra-ovarian and *in vitro* pollination; Modification of stigma surface, parasexual hybridization; Cybrids, *in vitro* fertilization.

Unit 7: Embryo, Endosperm and Seed (10 lectures)

Structure and types; General pattern of development of dicot and monocot embryo and endosperm; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo; Unusual features; Embryo development in *Paeonia*. Seed structure, importance and dispersal mechanisms

Units 8: Polyembryony and apomixis (4 lectures)

Introduction; Classification; Causes and applications.

3.11. Core P11: Reproductive Biology of Angiosperms

(Practical: Marks 15/Credits 2)

1. **Anther**: Wall and its ontogeny; Tapetum (amoeboid and glandular); MMC, spore tetrads, uninucleate, bicelled and dehisced anther stages through slides/micrographs, male germ unit (MGU) through photographs and schematic representation.

2. **Pollen grains**: Abnormal features of pollen grains: psuedomonads, polyads, pollinia (slides/photographs, fresh material); Ultrastructure of pollen wall (micrograph); Pollen viability: Tetrazolium test; Germination: Calculation of percentage germination in different media using hanging drop method.

3. **Ovule:** Types-anatropous, orthotropous, amphitropous/campylotropous, circinotropous, unitegmic, bitegmic; Tenuinucellate and crassinucellate; Special structures: Endothelium, obturator, hypostase, caruncle and aril (permanent slides/specimens/photographs).

4. Female gametophyte through permanent slides/ photographs: Types, ultrastructure of mature egg apparatus.

5. Intra-ovarian pollination; Test tube pollination through photographs.

6. **Endosperm:** Dissections of developing seeds for endosperm with free-nuclear haustoria.

7. **Embryogenesis:** Study of development of dicot embryo through permanent slides; dissection of developing seeds for embryos at various developmental stages; Study of suspensor through electron micrographs.

Suggested Readings

1. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms, VikasPublishing House. Delhi. 5th edition.
2. Shivanna, K.R. (2003). Pollen Biology and Biotechnology. Oxford and IBH Publishing Co. Pvt. Ltd. Delhi.
3. Raghavan, V. (2000). Developmental Biology of Flowering plants, Springer, Netherlands.
4. Johri, B.M. l (1984). Embryology of Angiosperms, Springer-Verlag, Netherlands.
5. Mishra, B.K., Dash, N. (2022). Reproductive Biology of Angiosperms. Kalyani Publishers, New Delhi.

3.12. Core T12: Plant Physiology
Course Code: SH/BOT/502/C-12

(Theory: Lecture 60/Credits 4/ Marks 25)

Course Learning Outcomes:

- Understand Water relation of plants with respect to various physiological processes.
- Explain chemical properties and deficiency symptoms in plants
- Explain the significance of nitrogen fixation
- Students acquire the adequate knowledge of translocation in plants.
- Explain the ATP-Synthesis
- Acquire adequate knowledge about plant growth regulators, phytochrome and flowering of plants.

Unit 1: Plant-water relations (10 lectures)
Water Potential and its components, water absorption by roots, aquaporins, pathway of water movement, symplast, apoplast, transmembrane pathways, guttation. Ascent of sap– cohesion-tension theory.Transpiration and factors affecting transpiration, antitranspirants, mechanism of stomatal movement.

Unit 2: Mineral nutrition (8 lectures)
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.

Unit 3: Nutrient Uptake (8 lectures)
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.

Unit 4: Translocation in the phloem (8 lectures)
Experimental evidence in support of phloem as the site of sugar translocation. Pressure–Flow Model; Phloem loading and unloading; Source–sink relationship.

Unit 5: Plant growth regulators (14 lectures)
Chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene, Brassinosteroids and Jasmonic acid.

Unit 6: Physiology of flowering (6 lectures)
Photoperiodism, flowering stimulus, florigen concept, vernalization, seed dormancy.

Unit 7: Phytochrome , crytochromes and phototropins (6 lectures)
Discovery, chemical nature, role in photomorphogenesis, low energy responses (LER) and high irradiance responses (HIR).

3.12. Core P12: Plant Physiology

(Practical: Marks 15/Credits 2)

1. Determination of isotonic concentration and osmotic pressure of plant cell sap by plasmolytic method.
2. Determination of water potential of given tissue (potato tuber) by weight method.
3. Study of the effect of humidity and light on the rate of transpiration in excised twig/leaf.
4. Determination of water absorption, retention and transpiration.
5. Calculation of stomatal index and stomatal frequency from the two surfaces of leaves of a mesophyte and xerophyte.
6. To study the phenomenon of seed germination (effect of light).
7. Study the effect of KNO_3 on stomatal opening.

Demonstration only

1. Demonstrate suction due to transpiration.
2. Fruit ripening/Rooting from cuttings.
3. Bolting experiment/*Avena* coleptile bioassay.

Suggested Readings

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons. U.S.A. 4th edition.
2. Taiz, L., Zeiger, E., Moller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
3. Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual. Narosa Publishing House, New Delhi.
4. Salisbury, F. B. and Ross, C. W. – Plant Physiology. Wordsworth Publishing Company.
5. Arun Chandra Sahu (2020). Plant Physiology and Metabolism, Kalyani Publishers.
6. Stryer, L. – Biochemistry, John Wiley & Sons.
7. Taiz, L. and Zeiger, E. – Plant Physiology. The Benjamin Cumming Publishing Company.
8. V. K. Jain. Fundamentals of Plant Physiology, S. Chand Pub.

Semester-VI

3.13. Core T13: Plant Metabolism
Course Code: SH/BOT/601/C-13

(Theory: Lecture 60/Credits 4/Marks 25)

Course Learning Outcomes:

- Understanding the metabolism of plants and enzymes with respect to various physiological processes.
- Explaination of chemical properties carbon compounds produced in plants
- Explaination of the significance of carbon metabolism in plants.
- Acquiring the adequate knowledge of metabolism in plants.
- Explaination of the ATP-Synthesis
- To acquiring adequate knowledge about nitrogen metabolism in plants.
- Explaination of the mechanism of signal transduction.

Unit 1: Concept of metabolism (6 lectures)
Introduction, anabolic and catabolic pathways, regulation of metabolism, role of regulatory enzymes (allosteric, covalent modulation and Isozymes).

Unit 2: Carbon assimilation (14 lectures)
Photosynthetic pigments, role of photosynthetic pigments (chlorophylls and accessory pigments), antenna molecules and reaction centres, photochemical reactions, photosynthetic electron transport, PSI, PSII, Q cycle, CO_2 reduction, photorespiration, C4 pathways; Crassulacean acid metabolism.

Unit 3: Carbohydrate metabolism (2 lectures)
Synthesis and catabolism of sucrose and starch.

Unit 4: Carbon Oxidation (10 lectures)
Glycolysis, fate of pyruvate, regulation of glycolysis, oxidative pentose phosphate pathway, oxidative decarboxylation of pyruvate, TCA cycle, amphibolic role, anaplerotic reactions, mitochondrial electron transport, oxidative phosphorylation, cyanide-resistant respiration, factors affecting respiration.

Unit 5: ATP-Synthesis (8 lectures)
Mechanism of ATP synthesis, oxidative and substrate level phosphorylation, chemiosmotic mechanism, ATP synthase.

Unit 6: Lipid metabolism (8 lectures)
Synthesis and breakdown of triglycerides, α oxidation and β-oxidation, glyoxylate cycle, gluconeogenesis and its role in mobilisation of lipids during seed germination.

Unit 7: Nitrogen metabolism (8 lectures)
Nitrate assimilation, biological nitrogen fixation (examples of legumes and non-legumes); Physiology and biochemistry of nitrogen fixation; Ammonia assimilation and transamination.

Unit 8: Mechanisms of signal transduction (4 lectures)
Receptor-ligand interactions; Second messenger concept, Calcium calmodulin.

3.13. Core P13: Plant Metabolism

(Practical: Marks 15/Credits 2)

1. Preparation of molar, molal & normal solution.
2. Chromatographic separation of photosynthetic pigments.
3. To study the effect of light intensity on the rate of photosynthesis.
4. Effect of carbon dioxide on the rate of photosynthesis.
5. To compare the rate of respiration in different parts of a plant.
6. RQ of different respiratory substrate of germinating seeds.
7. Seed Viability Test by TTC.

Suggested Readings

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. John Wiley and Sons. U.S.A. 4th edition.
2. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
3. Harborne, J.B. (1973). Phytochemical Methods. John Wiley & Sons. New York.
4. Sahu, A.C. (2020). Plant Physiology and Metabolism. Theory and Practical, Kalyani Publishers.
5. Nelson, D.L. and Cox, M.M. (2008). Lehninger Principles of Biochemistry, 5th Edition, W.H. Freeman and Company.
6. Stryer, L. – Biochemistry, John Wiley & Sons.
7. Conn, E. E. Stumpt, P. K. Bruening, G. and Doi, R. H., Cutline of Biochemistry, John Wiley & Sons .

3.14. Core T14: Plant Biotechnology
Course code: SH/BOT/602/C-14

(Theory: Lecture 60/Credits 4/Marks 25)

Course Learning Outcomes:

- Understand the core concepts and fundamentals of plant biotechnology and genetic engineering
- Develop their competency on different types of plant tissue culture
- Analyze the enzymes and vectors for genetic manipulations
- Examine gene cloning and evaluate different methods of gene transfer
- Critically analyze the major concerns and applications of transgenic technology
- To learn about gene cloning, recombinant DNA technology and bioinformatics includes recent biotechnological advancement related to genomics and proteomics.
- Acquire the knowledge about gene transfer and applications of biotechnology.
- Acquire the knowledge about tissue culture techniques, restriction digestion, isolation and electrophoresis of plasmid DNA.

Unit 1: Plant Tissue Culture (16 lectures)
Historical perspective; Composition of media; Nutrient and hormone requirements; Totipotency; Organogenesis; Embryogenesis (somatic and zygotic); Protoplast isolation, culture and fusion; Tissue culture applications (micropropagation, androgenesis, virus elimination, secondary metabolite production, haploids, triploids and hybrids; Cryopreservation; Germplasm Conservation).

Unit 2: Recombinant DNA technology (12 lectures)
Restriction Endonucleases, Types I-IV; Cloning Vectors: Prokaryotic (pUC18 and pUC19, pBR322, Ti plasmid, BAC); Lambda phage, Cosmid; Eukaryotic Vectors (YAC).

Unit 3: Gene Cloning (10 lectures)
Recombinant DNA, Bacterial Transformation and selection of recombinant clones; construction of genomic and cDNA libraries, screening DNA libraries to obtain gene of interest by genetic selection; colony hybridization; PCR

Unit 4: Methods of gene transfer (8 lectures)
Agrobacterium-mediated gene transfer, Direct gene transfer by Electroporation, Microinjection, Microprojectile bombardment.

Unit 5: Applications of Biotechnology (14 lectures)
Pest resistant (Bt-cotton) plant; herbicide resistant plants (Round Up Ready soybean); Transgenic crops with improved quality traits (Flavr Savr tomato, Golden rice); Role of transgenics in bioremediation (Superbug); Industrial enzymes (Aspergillase, Protease, Lipase); Gentically Engineered Products–Human Growth Hormone; Humulin; Biosafety concerns.

3.14. Core P14: Plant Biotechnology

(Practical: Marks 15/Credits 2)

1. (a) Preparation of MS medium.
   (b) Demonstration of *in vitro* sterilization and inoculation methods using leaf and nodal explants of *Datura*.
2. Study of anther, somatic embryogenesis & artificial seeds through photographs.
3. Study of methods of gene transfer through photographs: *Agrobacterium*-mediated, direct gene transfer by electroporation, microinjection, microprojectile bombardment.
4. Study of steps of genetic engineering for production of Bt cotton, Golden rice, Flavr Savr tomato through photographs.
5. Isolation of plasmid DNA (Demonstration).

Suggested Readings

1. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
2. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
3. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms. Vikas Publication House Pvt. Ltd., New Delhi. 5th edition.
4. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics. John Wiley and Sons, U.K. 5th edition.
5. Stewart, C.N. Jr. (2008). Plant Biotechnology & Genetics: Principles, Techniques and Applications. John Wiley & Sons Inc. U.S.A.

4. Discipline Specific Elective Courses

Semester-V

4.1. DSE-1 T1: Natural Resource Management
Course Code: SH/BOT/503/DSE-1

(Theory: Lecture 60/Credits 4/Marks 25)

Course Learning Outcomes:

- Understanding the idea of resources and examples of natural recourses.
- Development of the concept regarding the sustainability of using natural resources.
- Develop idea on national and international efforts in resource managements to make them sustainable.

Unit 1: Natural resources (2 lectures)
Definition and types.

Unit 2: Sustainable utilization (8 lectures)
Concept, approaches (economic, ecological and socio-cultural).

Unit 3: Land (8 lectures)
Utilization (agricultural, pastoral, horticultural, silvicultural); Soil degradation and management.

Unit 4: Water (8 lectures)
Fresh water (rivers, lakes, groundwater, aquifers, watershed); Marine; Estuarine; Wetlands; Threats and management strategies, potability of water

Unit 5: Biological Resources (12 lectures)
Biodiversity-definition and types; Significance; Threats; Management strategies; Bioprospecting; IPR; CBD; National Biodiversity Action Plan).

Unit 6: Forests (6 lectures)
Definition, Cover and its significance (with special reference to India); Major and minor Forest products; Depletion; Management.

Unit 7: Energy (6 lectures)
Renewable and non-renewable sources of energy with examples.

Unit 8: Contemporary practices in resource management (8 lectures)
EIA, GIS, Ecological Footprint with emphasis on carbon footprint, Resource Accounting; Waste management.

Unit 9: National and international efforts in resource management and conservation (4 lectures)

4.1. DSE-1 P1: Natural Resource Management

(Practical: Marks 15/Credits 2)

1. Estimation of solid waste generated by a domestic system (biodegradable and non biodegradable) and its impact on land degradation.
2. Collection of data on forest cover of specific area.
3. Measurement of dominance of woody species by DBH (diameter at breast height) method.
4. Calculation and analysis of ecological footprint.
5. Ecological modeling.
6. Field visits to local forest/river bed/water bodies/or related field.
7. Water potability test.

Suggested Readings

1. Vasudevan, N. (2006). Essentials of Environmental Science. Narosa Publishing House, New Delhi.
2. Singh, J. S., Singh, S.P. and Gupta, S. (2006). Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.
3. Rogers, P.P., Jalal, K.F. and Boyd, J.A. (2008). An Introduction to Sustainable Development. Prentice Hall of India Private Limited, New Delhi.

4.2. DSE-1 T2: Horticultural practices & Post Harvest Technology

Course code: SH/BOT/503/DSE-1

(Theory: Lecture 60 /Credits 6/Marks 40)

Course learning Outcomes

- Understanding the horticultural practices as a livelihood occupation.
- Establishment of the knowledge of using plants as economical, ornamental and aesthetic values.
- Knowledge of keeping the plant materials in storage and to visualize the post-harvest problems.
- To know the tricks of the trade of the horticultural products.

Unit 1: Introduction (4 lectures)

Definition and Scope of horticulture, Branches of horticulture; Role in economy.

Unit 2: Ornamental plants (4 lectures)

Types, classification (annuals, perennials, climbers and trees); Identification and salient features of some ornamental annuals - marigold, carnations, Petunias, Impatiens, Identification and salient features of some ornamental perennials - rose, gladiolus, orchids, gerberas, tuberose, *Chrysanthemum*, Cacti and Succulents (*Opuntia*, *Agave*), *Croton*. Identification and salient

features of some ornamental flowering climbers – *Ipomoeas, Quisqualis indica, Pyrostegia venusta, Aganosma caryophyllata, Bignonias.* Identification and salient features of some ornamental flowering trees - Indian Laburnum *(Cassia fistula*), Gulmohar (*Delonix regia*), *Jacaranda, Lagerstroemia*, Fishtail (*Caryota urens*) and areca palms, Semul (*Bombax ceiba*), Palash (*Butea monosperma*).

Unit 3: Fruit and vegetable crops (4 lectures)
Production, origin and distribution of major fruits and distribution of major vegetables. Management and marketing of vegetable and fruit crops; Identification of some fruits and vegetable varieties (citrus, banana, mango, Oranges, Chillies, Crucifers, Beans and Cucurbits).

Unit 4: Horticultural techniques (8 lectures)
Application of manure, fertilizers, nutrients and PGRs; Weed control; Biofertilizers, biopesticides; Irrigation methods (drip irrigation, surface irrigation, furrow and border irrigation); Hydroponics; Propagation Methods: asexual (grafting, cutting, layering, budding), sexual (seed propagation), Scope and limitations.

Unit 5: Landscaping and garden design (6 lectures)
Planning and layout (parks and avenues); gardening traditions - Ancient Indian, European,Mughal and Japanese Gardens; Urban forestry; policies and practices.

Unit 6: Floriculture (6 lectures)
Cut flowers, bonsai, commerce (market demand and supply); Importance of flower shows and exhibitions.

Unit 7: Post-harvest technology (10 lectures)
Importance of post harvest technology in horticultural crops; Evaluation of quality traits; Harvesting and handling of fruits, vegetables and cut flowers; Principles, methods of preservation and processing; Methods of minimizing loses during storage and transportation; Food irradiation - advantages and disadvantages; food safety.

Unit 8: Disease control and management (8 lectures)
Field and post-harvest diseases; Identification of deficiency symptoms; remedial measures and nutritional management practices; Crop sanitation; IPM strategies (genetic, biological andchemical methods for pest control); Quarantine practices; Identification of common diseases andpests of ornamentals, fruits and vegetable crops.

Unit 9: Horticultural crops - conservation and management (10 lectures)
Documentation and conservation of germplasm; Role of micropropagation and tissue culture techniques; Varieties and cultivars of various horticultural crops; IPR issues; National, international and professional societies and sources of information on horticulture.

4.2. DSE-1 P2: Horticultural practices & Post Harvest Technology

(Practical: Marks 15/Credits 2)

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1. Demonstration of Bonsai preparation
2. Propagation methods: cutting, layering, grafting.
3. Identification of some fruits and vegetable varieties (citrus, banana, mango, Oranges, Chillies, Crucifers, Beans and Cucurbits).
4. Field visits to gardens, standing crop sites, nurseries, vegetable gardens and horticultural fields at IARI or other suitable locations.

Suggested Readings

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.
6. Mandal, S., N(M)., S., Das, A. (2022). Horticulture Practices and Post-Harvest Technology, Books & Allied (P) Ltd. Kolkata.

4.3. DSE-2 T3 Agronomy
Course Code: SH/BOT/504/DSE-2

(Theory: Lecture 60/Credits 4/Marks 25)

Course Learning Outcomes:

- Understand the concept of agronomy and sustainable agriculture.
- Analyze different aspects diversified agriculture and farm enterprises, production technology of vegetation and flowers.
- Examine the implications integrated farming system along with production economics and farm management
- Evaluate the IT communication and diffusion of agricultural innovation.

Unit 1: Principles of crop production (16 lectures)
Definition and scope of Agronomy, Classification of Crops on Different basis, General principles of Crop production : Climate, soil and its preparation, seed and seed sowing, post-sowing tillage, water management, nutrition, plant protection measures, harvesting, threshing and storage, Agroforestry system, Agriculture, extension management.

Unit 2: Fundamentals of soil science (16 lectures)
Definition of Soil, Components of Soil and their role in agriculture, Physical properties of soil, and their significance, Chemical properties of soil, cation and anion exchange phenomenon and their importance in agriculture.

Unit 3: Agricultural Metereology (16 lectures)
Different meteorological variables related to agriculture, Rainfall- Hydrologic cycle and its components, Types and forms of precipitation, Humidity, definition, windvane, Anemo-meter, Indian Agro Climatic Zones Elementary idea of weather forecasting, etc.

Unit 4: Agricultural management and cultivation of some important crops (12 lectures)
Soil and water management, Integrated pest management, Post-harvest technology and value addition, Production economics and farm management; Manures, Fertilizers, Agrochemicals and Weed management, Cultivation and processing of the following crops: Rice, Wheat, Tea and Jute.

4.3. DSE-2 P3: Agronomy

(Practical: Marks 15/Credits 2)

1. Identification of soil types, soil texture, soil moisture, soil pH, Soil conductivity, organic and inorganic matter (C, NPK estimation by test kit).
2. Identification of major soil fauna (particularly nematodes)
3. Vermiculture and vermicomposting/ vermiwash (Visit a vermiculture farm or develop in the departmental farm house)
4. Determination of seed viability by TTC test.

Suggested Readings

1. Craig C. Sheaffer and Kristine M. Moncada (2012). Introduction to Agronomy-Food crops and Environment (Second Edition).
2. George Acquaah (2004). Principles of Crop production.
3. Reddy S.R. (2017). Principles of Agronomy.

4.4. DSE-2 T4: Stress Biology
Course code: SH/BOT/504/DSE-2

(Theory: Lecture 60/Credits 4/Marks 25)

Course Learning Outcomes:

- Develop the understanding of concept of stress, stress factors and resistance mechanisms.
- Explain different types of stress with examples.
- Develop the ability for critical appraisal of various physiological mechanisms that protect the plant from environmental stress i.e. adaptation, avoidance and tolerance.
- Analyze the role of production and scavenging mechanisms.

Unit 1: Defining plant stress (2 lectures)
Acclimation and adaptation.

Unit 2: Environmental factors (20 lectures)
Water stress; Salinity stress, High light stress; Temperature stress; Hypersensitive reaction; Pathogenesis– related (PR) proteins; Systemic acquired resistance; Mediation of insect and disease resistance by jasmonates.

Unit 3: Stress sensing mechanisms in plants (20 lectures)
Calcium modulation, Phospholipid signalling.

Unit 4: Developmental and physiological mechanisms that protect plants against environmental stress (12 lectures)
Adaptation in plants; Changes in root: shoot ratio; Aerenchyma development; Osmotic adjustment; Compatible solute production.

Unit 5: Reactive oxygen species–Production and scavenging mechanisms. (6 lectures)

4.4. DSE-2 P4: Stress Biology

(Practical: Marks 15/Credits 2)

1. Determination of osmotic potential (*Rhaoeo* leaf epidermal peelings) and RWC (Relative water content) in Leaves (any plant).
2. Detection of stress related compatible solutes viz. proline by colorimeter/spectrophotometric method in a plant under salinity stress.
3. Measurement of root: shoot ratio, and total wet weight of a plant under salt/drought stress
4. Effect of salt/temperature stress on seed viability and germination.

Suggested Readings

1. Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology. 4th edition.John Wiley and Sons. U.S.A.
2. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. 6th edition. Sinauer Associates Inc. USA.
3. Singh D.P. (2003).Stress Physiology. New Age International pvt. Ltd.

SEMESTER-VI

4.5. DSE-3 T5: Industrial & Environmental Microbiology
Course Code: SH/BOT/603/DSE-3

(Theory: Lecture 60 /Credits 4/Marks 25)

Course Learning Outcomes

- Allocation of microbes in industries and environmental management.
- Knowledge of economically important products by microbes using fermentation techniques.
- Establishment of idea using microbes in agriculture and pollution management.

Unit 1: Scope of microbes in industry and environment (6 lectures)

Unit 2: Bioreactors/Fermenters and fermentation processes (12 lectures)
Components of a typical bioreactor, Types of bioreactors-laboratory, pilotscale and production fermenters; Constantly stirred tank fermenter, tower fermenter, fixed bed and fluidized bed bioreactors and air-lift fermenter. Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous fermentations.
A visit to any educational institute/ industry to see an industrial fermenter, and other downstream processing operations.

Unit 3: Microbial production of industrial products (12 lectures)
Microorganisms involved, media, fermentation conditions, downstream processing and uses; Hands on microbial fermentations for the production and estimation (qualitative and quantitative) of Enzyme: amylase or lipase activity, Organic acid (citric acid or glutamic acid), alcohol (Ethanol) and antibiotic (Penicillin).

Unit 4: Microbial enzymes of industrial interest and enzyme immobilization (8 lectures)
Microorganisms for industrial applications and hands on screening microorganisms for casein hydrolysis; starch hydrolysis; cellulose hydrolysis. Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase**).**

Unit 5: Microbes and quality of environment.(6 lectures)
Distribution of microbes in air; Isolation of microorganisms from soil, air and water.

Unit 6: Microbial flora of water. (8 lectures)
Water pollution, role of microbes in sewage and domestic waste water treatment systems. Determination of BOD, COD, TDS and TOC of water samples; Microorganisms as indicators of water quality, check coliform and fecal coliform in water samples.

Unit 7: Microbes in agriculture and remediation of contaminated soils. (8 lectures)
Biological fixation; Mycorrhizae; Bioremediation of contaminated soils. Isolation of root nodulating bacteria, arbuscular mycorrhizal colonization in plant roots.

4.5. DSE-3 P5: Industrial & Environmental Microbiology

(Practical: Marks 15/Credits 2)

1. Principles and functioning of instruments in microbiology laboratory.
2. Hands on sterilization techniques and preparation of culture media.
3. Measurement of BOD.
4. Study of root nodule and isolation of root nodulating bacteria.
5. Demonstration of a common fermentor with photograph/ picture.
6. Industrial/academic institute visit

Suggested Readings

1. Pelzar, M.J. Jr., Chen E.C. S., Krieg, N.R. (2010). Microbiology: An application based approach. Tata McGraw Hill Education Pvt. Ltd., Delhi.
2. Tortora, G.J., Funke, B.R., Case. C.L. (2007). Microbiology. Pearson Benjamin Cummings, San Francisco, U.S.A. 9th edition.
3. Sandikar, B.M.(2021). Fundamental Microbiology, Books & Allied (P) Ltd., Kolkata.

4.6. DSE-3 T6: Bioinformatics
Course Code: SH/BOT/603/DSE-3

(Theory: Lecture 60 /Credits 4/Marks 25)

Course Learning Outcome:

- Uses of databases to study DNA and proteins sequence and their use in molecular phylogeny study.
- Understand algorithms for alignment of DNA sequences.
- Explain the structure of proteins homology modeling approach.
- Reflect upon the role of various models in prediction bio-molecul organization.

Unit 1: Introduction (8 lectures)
Introduction to bioinformatics; Types of data; Overview of various bioinformatics databases and resources; Application of bioinformatics.

Unit 2: Concepts of genomics and proteomics (14 lectures)
Genomes of model prokaryotes and eukaryotes; Protein coding genes; repeat sequences and single nucleotide polymorphisms.

Unit 3: Introduction to sequence alignment (14 lectures)
Local alignment, pair wise alignment, multiple sequence alignment, BLAST, CLUSTAL Omega, MAFFT, MUSCLE.

Unit 4: Phylogenetic analyses (14 lectures)
Evolution of genes and genomes, Clustering methods, Cladistics, Overview of Neighbor Joining, UPGMA, maximum parsimony and maximum likelihood methods, Software for phylogenetic analysis.

Unit 5: Structural bioinformatics (10 lectures)
Seccondary and tertiary structure prediction of proteins, Fold recognition, 3D structure quality assessment and structural alignments, Overview of PDB, PIR, ExPASY, SWISSMODEL, MODELLER, CHIMERA, PyMol, SPDV.

4.6. DSE-3 P6: Bioinformatics

(Practical: Marks 15/Credits 2)

1. Nucleic acid and protein sequence/structure databases. Sequence retrieval from databases.
2. Sequence alignment with BLAST.
3. Multiple sequence alignment with CLUSTAL Omega, MAFFT.
4. Construction and visualization of different types of phylogenetic trees with MEGA.
5. Determination of secondary structure of a protein using PSIPRED and PSSPRED.
6. 3D structure prdiction using SWISSMODEL and MODELLER. Visualization with PyMol and CHIMERA.
7. Assessment of the quality of protein 3D structure.

Suggested Readings

1. Arthur M. Lesk (2003). Introduction to Bioinformatics. Oxford University Press.
2. Selzer Paul Maria et al. (2012). Applied Bioinformatics: An Introduction. Springer.
3. Zhumur Ghosh and Bibekanand Mallick (2008). Bioinformatics: Principles and Applications. Oxford University Press.
4. Vinay Sharma, Ashok Munjal and Ashish Shanker (2018). A Text book of Bioinformatics. Rastogi Publications.
5. Ruchi Singh (2014). Bioinformatics: Genomics and Proteomics. Vikas Publishing House Private Limited.
6. Orpita Bosu and Simminder Kaur Thukral (2007). Bioinformatics, Databases, Tools and Algorithms. Oxford University Press.
7. Andreas D Baxevanis and B.F. Francis Ouellette (2009). Bioinformatics A Practical Guide to the Analysis of genes and proteins. Wiley Student Edition.

4.7. DSE-4 T7 Analytical Techniques in Plant Sciences
Course Code: SH/BOT/604/DSE-4

(Theory: Lecture 60/Credits 4/Marks 25)

Course Learning Outcomes:

- Develop conceptual understanding of cell wall degradation enzymes and cell fractionation.
- Classify different types of chromatography techniques.
- Explain the principles of Light microscopy, compound microscopy, Fluorescence microscopy and confocal microscopy
- Apply suitable strategies in data collections and disseminating research findings.

Unit 1: Cellular Fractionation and Separation Techniques (12 lectures)
Good laboratory practices, Cell fractionation, Sedimentation of cellular particles, type of centrifugation: Differential and density gradient centrifugation, type of rotors, Svedberg equation, Ultracentrifugation and applications.

Unit 2: Characterization of Biomolecules (18 lectures)
Principle; Paper chromatography; Column chromatography, TLC, GLC, HPLC, Ion exchange chromatography; Molecular sieve chromatography; Affinity chromatography. Electrophoresis: AGE, PAGE, SDS-PAGE.

Unit 3: Visualization Molecules in Living Cells (12 lectures)
Principles of microscopy; Light microscopy; compound microscopy, Fluorescence microscopy; Confocal microscopy; (b) Transmission and Scanning electron microscopy – sample preparation for electron microscopy, cryofixation, negative staining, shadow casting, freeze fracture, freeze etching.

Unit 4: Radiobiology, Colorimetry and Spectroscopy (18 lectures)
Use of radioisotopes in biological research, auto-radiography, Basic principles of Colorimetry and Spectrophotometry (Beer-Lambert Law), Instrumentation, Comparison between Colorimeter and Spectrophotometer, application of Colorimeter and Spectrophotometer in biological research.

4.7. DSE-4 P7 Analytical Techniques in Plant Sciences

(Practical: Marks 15/Credits 2)

1. Separation of amino acids by Course chromatography and identification of unknown sample.
2. Preparation of permanent slides (double staining) for microscopic studies of any plant tissue.
3. Demonstration of some Instruments: Centrifuge, Colorimeter/Spectrophotometer and Electrophoresis.

Suggested Readings

1. Plummer, D.T. (1996). An Introduction to Practical Biochemistry. 3rd edition. Tata McGraw-Hill Publishing Co. Ltd. New Delhi.
2. Ruzin, S.E. (1999). Plant Microtechnique and Microscopy, Oxford University Press, New York. U.S.A.
3. Ausubel, F., Brent, R., Kingston, R. E., Moore, D.D., Seidman, J.G., Smith, J.A., Struhl, K. (1995). Short Protocols in Molecular Biology. 3rd edition.
4. John Wiley & Sons.
5. Zar, J.H. (2012). Biostatistical Analysis. 4th edition. Pearson Publication. U.S.A.

4.8. DSE-4 T8: Research Methodology
Course Code: SH/BOT/604/DSE-4

(Theory: Lecture 60 /Credits 4/Marks 25)

Course Learning Outcomes:

- Understand the concept of research and different types of research in the context of biology.
- Develop laboratory experiment related skills.
- Develop competence on data collection and process of scientific documentation
- Analyze the ethical aspects of research.
- Evaluate the different methods of scientific writing and reporting.

Unit 1: Basic concepts of research (10 lectures)

Research-definition and types of research (Descriptive vs analytical; applied vs fundamental; quantitative vs qualitative; conceptual vs emperical).Research methods vs methodology. Literature-review and its consolidation; Library research; field research; laboratory research.

Unit 2: General laboratory practices (12 lectures)

Common calculations in botany laboratories. Understanding the details on the label of reagent bottles. Molarity and normality of common acids and bases.Preparation of solutions. Dilutions. Percentage solutions. Molar, molal and normal solutions.Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures in their handling.

Unit 3: Data collection and documentation of observations (6 lectures)

Maintaining a laboratory record; Tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars. The art of field photography.

Unit 4: Overview of Biological Problems (6 lectures)

History; Key biology research areas, Model organisms in biology (A Brief overview): Genetics, Physiology, Biochemistry, Molecular Biology, Cell Biology, Genomics, Proteomics-Transcriptional regulatory network.

Unit 5: **Methods to study plant cell/tissue structure (6 lectures)**

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

Unit 6: Plant microtechniques (12 lectures)

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

Unit 7: The art of scientific writing and its presentation (8 lectures)
Numbers, units, abbreviations and nomenclature used in scientific writing. Writing references. Powerpoint presentation. Poster presentation. Scientific writing and ethics, Introduction to copyright-academic misconduct/plagiarism.

4.8. DSE-4 P8: Research Methodology

(Practical: Marks 15/Credits 2)

1. Experiments based on chemical calculations.
2. Plant microtechnique experiments.
3. The art of imaging of samples through microphotography and field photography.
4. Poster presentation on defined topics.
5. Technical writing on topics assigned.

Suggested Readings

1. Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.
2. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice development Association, Hong Kong.
3. Ruzin, S.E. (1999). Plant microtechnique and microscopy. Oxford University Press, New York, U.S.A.

5. Skill Enhancement Courses

SEMESTER-III

5.1. SEC-1 T1: Biofertilizers
Course Code: SH/BOT/305/SEC-1

(Theory: Lecture 30/ Credits 2/Marks 40)

Course Learning Outcomes:

- Know about Biofertilizers which are best defined as biologically active products which help in crop production without any side effects.
- Aware about social justice and wellbeing of rural communities.
- Develop concepts regarding green manuring and organic fertilizers.
- Develop good public health and food security.
- Develop financial sequirity.
- Develop knowledge about vermicomposting and VAM for better crop production.

Unit 1: (4 lectures)
General account about the microbes used as biofertilizer. Rhizobium: isolation, identification, mass multiplication, carrier based inoculants. Actinorrhizal symbiosis.

Unit 2: (8 lectures)
Azospirillum: Isolation and mass multiplication, carrier based inoculant, associative effect of different microorganisms. *Azotobacter*: isolation, identification, mass multiplication, carrier based inoculants.

Unit 3: (4 lectures)
Cyanobacteria (blue green algae), *Azolla* and *Anabaena azollae* association, blue green algae(BGA) and *Azolla* in rice cultivation

Unit 4: (8 lectures)
Mycorrhizal association, types of mycorrhizal association, VAM: isolation and inoculum production of VAM, and its influence on growth and yield of crop plants.

Unit 5: (6 lectures)
Organic farming: Green manuring and organic fertilizers; Recycling of biodegradable municipal, agricultural and Industrial wastes – biocompost making methods; Types and method of vermicomposting, its field Application.

Suggested Readings

1. Dubey, R.C., 2005 A Text book of Biotechnology S.Chand & Co, New Delhi.
2. Kumaresan, V. 2005, Biotechnology, Saras Publications, New Delhi.
3. John Jothi Prakash, E. 2004. Outlines of Plant Biotechnology. Emkay _Publication, NewDelhi.
4. Sathe, T.V. 2004 Vermiculture and Organic Farming. Daya publishers.
5. Subha Rao, N.S. 2000, Soil Microbiology, Oxford & IBH Publishers, New Delhi.
6. Vayas,S.C, Vayas, S. and Modi, H.A. 1998 Bio-fertilizers and Organic Farming, Akta Prakashan, Nadiad.
7. Acaharya, K., Sen, S., Rai, M. (20190 Biofertilizers and Biopesticides, Techno World, Kolkata.

5.2. SEC-1 T2: Herbal Technology
Course Code: SH/BOT/305/SEC-1

(Theory: Lecture 30/ Credits 2/Marks 40)

Course Learning Outcomes:

- Develop knowledge about the medicinal values of different plants.
- Understand about the medicinal plants, its active components, uses.
- Develop knowledge about drug adulteration.
- Understand phytochemical screening tests for secondary metabolites.
- Develop knowledge about micro propagation of important medicinal plant species.

Unit 1: (6 Lectures)
Herbal medicines: history and scope - definition of medical terms - role of medicinal plants in Siddha systems of medicine; cultivation - harvesting - processing - storage - marketing and utilization of medicinal plants.

Unit 2: (6 Lectures)
Pharmacognosy - systematic position medicinal uses of the following herbs in curing various ailments; Tulsi, Ginger, Fenugreek, Indian Goose berry and Ashoka.

Unit 3: (6 Lectures)
Phytochemistry - active principles and methods of their testing - identification and utilization of the medicinal herbs; *Catharanthus roseus* (cardiotonic), *Withania somnifera* (drugs acting on nervous system), *Clerodendron phlomoides* (anti-rheumatic) and *Centella asiatica* (memory booster).

Unit 4: (8 Lectures)
Analytical pharmacognosy: Drug adulteration - types, methods of drug evaluation - Biological testing of herbal drugs - Phytochemical screening tests for secondary metabolites (alkaloids, flavonoids, steroids, triterpenoids, phenolic compounds).

Unit 5: (4 Lectures)
Medicinal plant banks micro propagation of important species (*Withania somnifera*, neem and tulsi) Herbal foods-future of pharmacognosy.

Suggested Readings

1. Glossary of Indian medicinal plants, R.N.Chopra, S.L.Nayar and I.C.Chopra, 1956. C.S.I.R, New Delhi.
2. The indigenous drugs of India, Kanny, Lall, Dey and Raj Bahadur, 1984. International Book Distributors.
3. Herbal plants and Drugs Agnes Arber, 1999. Mangal Deep Publications.
4. Ayurvedic drugs and their plant source. V.V. Sivarajan and Balachandran Indra 1994. Oxford IBH publishing Co.
5. Ayurveda and Aromatherapy. Miller, Light and Miller, Bryan, 1998. Banarsidass, Delhi.
6. Principles of Ayurveda, Anne Green, 2000. Thomsons, London.
7. Pharmacognosy, Dr.C.K.Kokate et al. 1999. Nirali Prakashan.

SEMESTER- IV

5.3. SEC-2 T3: Mushroom Culture Technology

Course Code: SH/BOT/405/SEC-2

(Theory: Lecture 30/ Credits 2/Marks 40)

Course Learning Outcomes

- Idea about various types and categories of mushrooms as edible staff.
- Demonstrate various types of mushroom cultivating technologies.
- Value the economic factors associated with mushroom cultivation.

Unit 1: (5 Lectures)
Introduction, history, Nutritional and medicinal value of edible mushrooms; Poisonous mushrooms .Types of edible mushrooms available in India *Volvariella volvacea, Pleurotus citrinopileatus, Agaricus bisporus.*

Unit 2: (12 Lectures)
Cultivation Technology: Infrastructure: substrates (locally available) Polythene bag, vessels, Inoculation hook, inoculation loop, low cost stove, sieves, culture rack, mushroom unit (Thatched house) water sprayer, tray, small polythene bag. Pure culture: Medium, sterilization, preparation of spawn, multiplication. Mushroom bed preparation-paddy straw, sugarcane trash, maize straw, banana leaves. Factors affecting the mushroom bed preparation-

Low cost technology, Composting technology in mushroom production. Mushroom weeds and pest and its control.

Unit 3: (8 Lectures)
Storage and nutrition: Short-term storage (Refrigeration-up to 24 hours) Long term Storage (canning, pickels, papads), drying, storage in salt solutions. Nutrition-Proteins-amino acids, mineral elements nutrition- Carbohydrates, Crude fibre content-Vitamins.

Unit 4: (5 Lectures)
Food Preparation: Types of foods prepared from mushroom. Research Centres-National level and Regional level. Cost benefit ratio- Marketing in India, Export Value.

Suggested Readings

1. Marimuthu, T. Krishnamoorthy, A.S. Sivaprakasam, K. and Jayarajan. R (1991) Oyster Mushrooms, Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore.
2. Swaminathan,M.(1990) Food and Nutrition. Bappco, The Bangalore Printingand Publishing Co.Ltd., No.88, Mysore Road, Bangalore-560018.
3. Tewari, Pankaj Kapoor, S.C.,(1988). Mushroom cultivation, Mittal Publications, Delhi.
4. Nita Bahl (1984-1988) Handbook of Mushrooms, II Edition, Vol.I & Vol.II.
5. B. C. Suman and V. P. Sharma (2011): Mushroom cultivation and Uses (Agrobios)
6. V. N. Pathak, N. Yadav and M. Gaur. (2011):Mushroom Production and Processing Technology (Agrobios)
7. Reeti Singh and U. C. Singh (2011): Modern Mushroom cultivation (Agrobios)

5.4. SEC-2 T4: Medicinal Botany
Course Code: SH/BOT/405/SEC-2

(Theory: Lecture 30/ Credits 2/Marks 40)

Course Learning Outcome

- Establishment of knowledge about the medicinal plants though past and involvement of ethnic concept in interdisciplinary science.
- Establishment of methodology of ethnobotany studies.
- Knowledge of local medicinal plants and increase in interest on them.

Unit 1: (8 Lectures)
History, Scope and Importance of Medicinal Plants; Indigenous Medicinal Sciences; Definition and Scope.
Ayurveda: History, origin, panchamahabhutas, saptadhatu and tridosha concepts, Rasayana, plants used in ayurvedic treatments,

Siddha: Origin of Siddha medicinal systems, Basis of Siddha system, plants used in Siddha medicine.
Unani: History, concept: Umoor-e- tabiya, tumors treatments/ therapy, polyherbal formulations.

Unit 2: (8 Lectures)
Definition: endemic and endangered medicinal plants; Red list criteria; Conservation of endangered and endemic medicinal plants; In situ conservation: Biosphere reserves, sacred groves, National Parks; Ex situ conservation: Botanic Gardens, Ethnomedicinal plant Gardens.
Propagation of Medicinal Plants: Objectives of the nursery, its classification, important components of a nursery, sowing, pricking, use of green house for nursery production, propagation through cuttings, layering, grafting and budding.

Unit 3: (8 Lectures)
Definition; Ethnobotany and Folk medicines; Ethnobotany in India: Methods to study ethnobotany; Applications of Ethnobotany: National interacts, Palaeo-ethnobotany; folk medicines of ethnobotany, ethnomedicine, ethnoecology, ethnic communities of India. Application of natural products to certain diseases- Jaundice, cardiac, infertility, diabetics, Blood pressure and skin diseases.

Unit 4: (6 Lectures)
Study of local medicinal plants with proven medicinal properties: (Parts used and uses only)
1. Neem 2. Tulasi 3. Drumstick (Sojney-Moringa) 4. Fenugreek (Methi) 5. Periwinkle (Vinca) 6. Gooseberry (Amla) 7. Bael (Aegle) 8. Centella (Thankuni) 9. Sweet flag (Bach) 10.Gymnema 11. Cynodon (Durba ghas) 12. Aloe vera 13. Tinospora (Gulancha lata) 14. Ashwagandha 15. Kalmegh 16. Bahera 17. Haritaki.

Suggested Readings

1. Trivedi P C, 2006. Medicinal Plants: Ethnobotanical Approach, Agrobios, India.
2. Purohit and Vyas, 2008. Medicinal Plant Cultivation: A Scientific Approach, 2nd edn. Agrobios, India.

6. Generic Elective Courses

SEMESTER-I

6.1. GE-1 T1: Plant Biodiversity [Microbes, Algae, Fungi & Archegoniate]
Course Code: SH/BOT/103/GE-1

(Theory: Lecture 60/Credits 4/Marks 25)

Course Learning Outcomes:

- Study characterization and economic importance of various groups of algae.
- Develop understanding on the concept of microbes their nutrition, growth, metabolism, reproduction and recombination process.
- Prepare microbial samples for microscopic observation and temporary and permanent slides for different algal samples.
- Understand the economic importance of microbes in human welfare.
- Understand the concept of extinct and extant primitive archegoniates (Bryophytes, Pteridophytes & Gymnosperms).
- Understand about the morphology, anatomy of different vegetative parts and reproductive organs with life cycle of different genus.
- Gather Knowledge about the evolution among the plants and evolution of land plants.

Unit 1: Microbes (10 lectures, Marks-4)
Viruses – General characters of virus; Structure of DNA virus (T-phage); Lytic and lysogenic cycle; Structure of RNA virus (TMV); Economic importance of viruses; General characteristics and cell structure of bacteria; Reproduction – vegetative, asexual and recombination (conjugation, transformation and transduction); Economic importance of bacteria.

Unit 2: Algae (12 lectures, Marks-4)
General characteristics; Range of thallus organization and reproduction; Morphology and life-cycles of the following: *Oedogonium*, *Vaucheria*, *Fucus*, *Polysiphonia*. Economic importance of algae.

Unit 3: Fungi (12 lectures, Marks-5)
Introduction- General characteristics, life cycle of Mucor (Zygomycota), *Penicillium* (Ascomycota), *Agaricus* (Basidiomycota); General characters of Lichens; Mycorrhiza: ectomychorrhiza and endomycorrhiza and their significance

Unit 4: Introduction to Archegoniate (2 lectures)
Unifying features of archegoniates, Transition to land habit, Alternation of generations.

Unit 5: Bryophytes (10 lectures, Marks-4)
General characteristics, morphology, anatomy and reproduction of *Marchantia* and *Funaria*.(Developmental details not to be included). Ecology and economic importance of bryophytes with special mention of *Sphagnum*.

Unit 6: Pteridophytes (8 lectures, Marks-4)
General characteristics, morphology, anatomy and reproduction of *Selaginella*, *Equisetum* and *Pteris*.(Developmental details not to be included). Ecological and economical importance of Pteridophytes.

U nit 7: Gymnosperms (6 lectures, Marks-4)
General characteristics; morphology, anatomy and reproduction of *Cycas* and *Pinus* (Developmental details not to be included). Ecological and economical importance.

6.1. GE-1 P1: Plant Biodiversity [Microbes, Algae, Fungi, Archegoniate (Bryophyta, Pteridophyta, & Gymnosperm)]

(Practical: Marks 15/ Credits2)

1. EMs/Models of viruses – T-Phage and TMV, Line drawing/Photograph of Lytic and Lysogenic Cycle.
2. Simple staining process by carbol fuchsin.
3. Study of vegetative and reproductive structures of *Nostoc, Oedogonium, Oscillatoria,* through temporary preparations and *Fucus & Polysiphonia* - Specimen and permanent slides
4. ***Mucor and Penicillium***: Asexual stage from temporary mounts and sexual Structures through permanent slides.
5. ***Puccinia*****:** Herbarium specimens of Black Stem Rust of Wheat and infected *Justicia* leaves; section/tease mounts of spores on Justicia leaf and permanent slides of different spore forms.
6. ***Agaricus*****:** Specimens of button stage and full grown mushroom; Sectioning of gills of *Agaricus*.
7. ***Marchantia***: morphology of thallus, v.s.of thallus through gemma cup, l.s of sporophyte (permanent slides).
8. ***Funaria*****:** morphology, permanent slides showing antheridial and archegonial heads, l.s of capsule from permanent slide.
9. ***Selaginella*****:** morphology, t.s.of stem, l.s of strobilus (from permanent slide).
10. ***Pteris*****:** morphology, v.s. of sporophyll.
11. ***Cycas*****:** morphology t.s.of rachis, v.s.of leaflet, l.s of ovule (permanent slide).
12. ***Pinus*****:** morphology t.s. of needle, t.s.of stem, l.s./t.s.of male cone, l.s. of female cone.

Suggested Readings

1. J.N.Mitra, D.Mitra, S.K.Chowdhuri . Studies in Botany Vol 1. Moulik Library
2. Bhattacharya, Hait,Ghosh. A Text Book of Botany. Vol 2. NCBA.
3. Hait, Bhattacharya,Ghosh. A Text Book of Botany. Vol 1. NCBA.
4. Bijaya Kumar Mishra, Nirupama Dash. Microbiology and Phycology 2019. Kalyani Publishers.
5. B.R.Vashishta, A.K.Sinha. Botany for Degree students-FUNGI/ALGAE/Pteridophytes/ Gymnosperms. S.Chand & Company.
6. Baman Chandra Acharya. Archegoniates (2020) . Kalyani Publishers
7. Bhatnagar, S.P. and Moitra, A. (1996). Gymnosperms. New Age International (P) Ltd Publishers, New Delhi, India.

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SEMESTER- II

6.2. GE-2 T2: Genetics and Plant Breeding
Course Code: SH/BOT/203/GE-2

(Theory: Lectures: 60/Credits 4/ Marks 25)

Course Learning Outcomes:

- Have conceptual understanding of laws of inheritance, genetic basis of loci and alleles and their linkage.
- Comprehend the effect of chromosomal abnormalities in numerical as well as structural changes leading to genetic disorders.
- Develop critical understanding of chemical basis of genes and their interactions at population and evolutionary levels.
- Analyze the effect of mutations on gene functions and dosage.

Unit 1: Heredity (20 Lectures)

Brief life history of Mendel; Terminologies; Laws of Inheritance; Modified Mandelian Ratios: 1:2:1- Co- dominance, incomplete dominance, 9:7, 12:3:1; Chi Square; Multiple allelism; Chromosome theory of Inheritance.

Unit 2: Sex-determination and Sex-linked Inheritance (4 Lectures)

Unit 3: Linkage and Crossing over (8 Lectures)
Linkage: concept & history, complete & incomplete linkage, bridges experiment, coupling & repulsion, recombination frequency, linkage maps based on two and three factor crosses. Crossing over: concept and significance, cytological proof of crossing over.

Unit 4: Mutations and Chromosomal Aberrations (6 Lectures)
Types of mutations, effects of physical & chemical mutagens. Numerical chromosomal changes: Euploidy, Polyploidy and Aneuploidy; Structural chromosomal changes: Deletions, Duplications, Inversions & Translocations.

Unit 5: Plant Breeding (4 lectures)
Introduction and objectives. Breeding systems: modes of reproduction in crop plants. Important achievements and undesirable consequences of plant breeding.

Unit 6: Methods of crop improvement (10 lectures)
Introduction: Centres of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self pollinated, cross pollinated and vegetatively propagated plants; Hybridization: For self, cross and vegetatively propagated plants– Procedure, advantages and limitations.

Unit 7: Inbreeding depression and heterosis (4 lectures)
History, genetic basis of inbreeding depression and heterosis; Applications.

Unit 8: Crop improvement and breeding (4 lectures)
Role of mutations; Polyploidy; Distant hybridization and role of biotechnology in crop improvement.

6.2. GE-2 P2: Genetics and Plant Breeding

(Practical: Credits 2 / Marks 15)

1. Mendel's laws through seed ratios. Laboratory exercises in probability and chi- square.
2. Incomplete dominance and gene interaction through seed ratios (9:7; 12:3:1).
3. Study of aneuploidy: Down's, Klinefelter's and Turner's syndromes through photographs.
4. Photographs/Permanent Slides showing Translocation Ring, Laggards and Inversion Bridge.
5. Hybridization techniques - Emasculation, Bagging (For demonstration only).

Suggested Readings

1. Gardner EJ, Simmons MJ, Snustad DP (2008). Principles of Genetics. 8th Ed. Wiley- India.
2. Snustad, D.P. and Simmons, M.J. (2010). Principles of Genetics, 5th edition, John Wiley & Sons Inc., India,
3. Klug WS, Cummings MR, Spencer, C, Palladino, M (2011). Concepts of Genetics, 10th Ed., Benjamin Cummings
4. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.
5. Pierce BA (2011) Genetics: A Conceptual Approach, 4th Ed., Macmillan Higher Education Learning
6. Singh, B.D. (2005). Plant Breeding: Principles and Methods. Kalyani Publishers. 7th edition.
7. Chaudhari, H.K. (1984). Elementary Principles of Plant Breeding. Oxford – IBH. 2nd edition.
8. Acquaah, G. (2007). Principles of Plant Genetics & Breeding. Blackwell Publishing.

6.3. GE-2 T3: Plant Anatomy & Embryology

Course Code: SH/BOT/203/GE-2

(Theory: Lecture 60 /Credits 4/Marks 25)

Plant Anatomy (Marks-13)

Unit 1: Meristematic and permanent tissues (8 lectures)
Root and shoot apical meristems; Simple and complex tissues, Tissue Systems.

Unit 2: Organs (4 lectures)
Structure of dicot and monocot root stem and leaf.

Unit 3: Secondary Growth (8 lectures)
Vascular cambium – structure and function, seasonal activity. Secondary growth in root and stem, Wood (heartwood and sapwood).

Unit 4: Adaptive and protective systems (8 lectures)
Epidermis, cuticle, stomata; General account of adaptations in xerophytes and hydrophytes.

Embryology (Marks-12)

Unit 5: Structural organization of flower (8 lectures)
Structure of anther and pollen; Structure and types of ovules; Types of embryo sacs, organization and ultrastructure of mature embryo sac.

Unit 6: Pollination and fertilization (8 lectures)
Pollination mechanisms and adaptations; Double fertilization; Seed-structure appendages and dispersal mechanisms.

Unit 7: Embryo and endosperm (8 lectures)
Endosperm types, structure and functions; Dicot and monocot embryo; Embryo endosperm Relationship.

Unit 8: Apomixis and polyembryony (8 lectures)
Definition, types and Practical applications

6.3. GE-2 P3: Plant Anatomy & Embryology

(Practical: Marks 15/Credits 2)

Plant Anatomy (Marks-10)

1. Study of meristems through permanent slides and photographs.
2. Tissues (parenchyma, collenchyma and sclerenchyma); Macerated xylary elements, Phloem (Permanent slides, photographs).
3. Stem: Monocot: *Zea mays;* Dicot: *Helianthus*; Secondary: *Helianthus* (only Permanent slides).
4. Root: Monocot: *Zea mays*; Dicot: *Helianthus*; Secondary: *Helianthus* (only Permanent slides).
5. Leaf: Dicot and Monocot leaf (only Permanent slides).
6. Adaptive anatomy: Xerophyte (*Nerium* leaf); Hydrophyte (*Hydrilla* stem).

Embryology (Marks-5)

7. Structure of anther (young and mature), tapetum (amoeboid and secretory) (Permanent slides).
8. Types of ovules: anatropous, orthotropous, circinotropous, amphitropous/ Campylotropous (from permanent slide).
9. Female gametophyte: *Polygonum* (monosporic) type of Embryo sac Development (Permanent slides/photographs).
10. Pollen morphology: Impatiens, Hibiscus (from permanent slide)
11. Dissection of embryo/endosperm from developing seeds.
12. Calculation of percentage of germinated pollen in a given medium.

Suggested Readings

1. Bhojwani, S.S. & Bhatnagar, S.P. (2011). Embryology of Angiosperms. Vikas Publication House Pvt. Ltd. New Delhi. 5th edition.
2. Mauseth, J.D. (1988). Plant Anatomy. The Benjamin/Cummings Publisher, USA.

SEMESTER- III

6.4. GE-3 T4: Plant Ecology, Morphology & Taxonomy
Course Code: SH/BOT/304/GE-3

(Theory: Lecture 60/Credits 4/Marks 25)

Course Learning Outcomes:

- Classify Plant systematics and recognize the importance of herbarium.
- Evaluate the Important herbaria and botanical gardens.
- Interpret the rules of ICN in botanical nomenclature.
- Generalize the characters of the families according to artificial, natural and phylogenetic classification.

Plant Ecology (30 Lectures, Marks-10)

Unit 1: Introduction (2 lectures)

Unit 2: Ecological factors (10 lectures)
Soil: Origin, formation, composition, soil profile. Water: States of water in the environment, precipitation types. Light and temperature: Variation Optimal and limiting factors; Shelford law of tolerance. Adaptation of hydrophytes and xerophytes.

Unit 3: Plant communities (6 lectures)
Characters; Ecotone and edge effect; Succession; Processes and types.

Unit 4: Ecosystem (8 lectures)
Structure; energy flow trophic organisation; Food chains and food webs, Ecological pyramids production and productivity; Biogeochemical cycling; Cycling of carbon, nitrogen and Phosphorous.

Unit 5: Phytogeography (4 lectures)
Principle biogeographical zones; Endemism.

Taxonomy (30 Lectures, Marks-15)

Unit 6: Morphology (4 Lectures)
Leaves- Types , Phyllotaxy; Inflorescence – Defition and types; Flower – Different parts; Fruits - Defition and types

U nit 7: Introduction to plant taxonomy (2 lectures)
Identification, Classification, Nomenclature.

Unit 8: Identification (4 lectures)
Functions of Herbarium, important herbaria and botanical gardens of the world and India; Documentation: Flora, Keys: single access and multi-access

Unit 9: (5 lectures)
Taxonomic evidences from palynology, cytology, phytochemistry and molecular data.

Unit 10: Taxonomic hierarchy (2 lectures)
Ranks, categories and taxonomic groups

U nit 11: Botanical nomenclature (5 lectures)
Principles and rules (ICN); ranks and names; binominal system, typification, author citation, valid publication, rejection of names, principle of priority and its limitations.

Unit 12: Classification (4 lectures)
Types of classification-artificial, natural and phylogenetic. Bentham and Hooker (upto series), Engler and Prantl (upto series).

Unit 13: (4 Lectures)
General characters and economic importance of the following families (range of floral structure excluded): Magnoliaceae, Brassicaceae, Malvaceae, Euphorbiaceae, Fabaceae, Apocynaceae, Lamiaceae, Solanaceae, Rubiaceae, Asteraceae, Poaceae, Orchidaceae

6.4. GE-3 P4: Plant Ecology & Taxonomy

(Practical: Marks 15/Credits 2)

Plant Ecology (Marks-6)

1. Study of instruments used to measure microclimatic variables: Soil thermometer, maximum and minimum thermometer, anemometer, psychrometer/hygrometer, rain gauge and lux meter.

2. Determination of pH, and analysis of two soil samples for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency by rapid field test.

3. Ecological adaptations of some species: *Ipomoea aquatica* stem, *Nerium* leaf and *Vanda* root.

4. Determination of minimal quadrat size for the study of herbaceous vegetation in the college campus by species area curve method. (species to be listed).

5. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law.

Taxonomy (Marks-9)

6. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagram/s, floral formula/e and systematic position according to Bentham & Hooker's system of classification): Brassicaceae, Asteraceae, Solanaceae, Lamiaceae, Malvaceae, Rubiaceae, Fabaceae, Apocynaceae. Acanthaceae, Verbenaceae.

7. Field visit (local) – Excursion/Field trips are to be organized in Botanically rich areas. A field report with photographic document of plants (atleast 10) and corresponding field record to be submitted during practical examination

8. Mounting of a properly dried and pressed specimen of any one wild plant with herbarium label (to be submitted in the record book).

Suggested Readings

1. Kormondy, E.J. (1996). Concepts of Ecology. Prentice Hall, U.S.A. 4th edition.
2. Sharma, P.D. (2010) Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
3. Simpson, M.G. (2006). *Plant Systematics.* Elsevier Academic Press, San Diego, CA, U.S.A.
4. Singh, G. (2012). *Plant Systematics:* Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition.

6.5. GE-3 T5: Cell and Molecular Biology
Course Code: SH/BOT/304/GE-3

(Theory: Lectures: 60/Credits 4/Marks 25)

Unit 1: Techniques in Biology (8 Lectures)
Principles of microscopy; Light Microscopy; Phase contrast microscopy; Electron microscopy (EM)- Scanning EM and Scanning Transmission EM (STEM).

Unit 2: Cell as a unit of Life (2 Lectures)
The Cell Theory; Prokaryotic and eukaryotic cells; Cell size and shape; Eukaryotic Cell components.

Unit 3: Cell Organelles (20 Lectures)
Mitochondria: Structure, Semiautonomous nature; Symbiont hypothesis; mitochondrial DNA. Chloroplast Structure, semiautonomous nature, chloroplast DNA. ER, Golgi body & Lysosomes: Nucleus: Nuclear Envelope- structure of nuclear pore complex; chromatin; molecular organization, DNA packaging in eukaryotes, euchromatin and heterochromatin, nucleolus and ribosome structure (brief).

Unit 4: Cell Membrane and Cell Wall (6 Lectures)
The functions of membranes; Models of membrane structure; The fluidity of membranes;

Membrane proteins and their functions; Carbohydrates in the membrane; Faces of the membranes; Selective permeability of the membranes; Cell wall.

Unit 5: Cell Cycle (4 Lectures)
Overview of Cell cycle, Mitosis and Meiosis; Molecular controls.

Unit 6: Genetic material (8 Lectures)
DNA: Hershey-Chase bacteriophage experiment, DNA structure, types of DNA, types of genetic material. DNA replication (Prokaryotes): bidirectional replication, semi–conservative, semi discontinuous, RNA priming, replication of linear, ds- DNA, replicating the 5′ end of linear chromosome including replication enzymes.

Unit 7: Transcription (Prokaryotes and Eukaryotes) (8 Lectures)
Types of structures of RNA (mRNA, tRNA, rRNA), RNA polymerase- various types; Translation (Prokaryotes and eukaryotes), genetic code.

Unit 8: Regulation of gene expression (4 Lectures)
Prokaryotes: Lac operon Concept.

6.5. GE-3 P5: Cell and Molecular Biology

(Practical: Credits 2/Marks 15)

1. To study prokaryotic cells (bacteria), viruses, eukaryotic cells with the help of light and electron micrographs.
2. Study of the photomicrographs of cell organelles.
3. To study the structure of plant cell through temporary mounts.
4. Study of mitosis and meiosis (temporary mounts and permanent slides).
5. Study of plasmolysis and deplasmolysis on *Rhoeo* leaf.
6. Study the structure of nuclear pore complex by photograph (from Gerald Karp)
7. Study of special chromosomes (polytene & lampbrush) either by slides or photographs.
8. Study DNA packaging by micrographs.

Suggested Readings

1. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009. The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

SEMESTER-IV

6.6. GE-4 T6: Plant Physiology & Metabolism
Course Code: SH/BOT/404/GE-4

(Theory: Lecture 60 /Credits 4/Marks 25)

Course Learning Outcomes:

- Understand Water relation of plants with respect to various physiological processes.
- Explain chemical properties and deficiency symptoms in plants.
- Classify aerobic and anaerobic respiration.
- Explain the significance of Photosynthesis and respiration.
- Assess dormancy and germination of seeds.
- To acquire adequate knowledge about translocation in plants, carbon dioxide concentrating mechanisms, growth regulators and flowering of plants.

Unit 1: Plant-water relations (8 lectures)
Importance of water, water potential and its components; Transpiration and its significance; Factors affecting transpiration; Root pressure and guttation.

Unit 2: Mineral nutrition (8 lectures)
Essential elements, macro and micronutrients; Criteria of essentiality of elements; Role of essential elements; Transport of ions across cell membrane, active and passive transport, carriers, channels and pumps.

Unit 3: Translocation in phloem. (6 lectures)
Composition of phloem sap, girdling experiment; Pressure flow model; Phloem loading and unloading.

Unit 4: Photosynthesis (12 lectures)
Photosynthetic Pigments (Chl a, b, xanthophylls, carotene); Photosystem I and II, reaction center, antenna molecules; Electron transport and mechanism of ATP synthesis; C3, C4 and CAM pathways of carbon fixation; Photorespiration.

Unit 5: Respiration (6 lectures)
Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate, Oxidative Pentose Phosphate Pathway.

Unit 6: Enzymes (4 lectures)
Structure and properties; Mechanism of enzyme catalysis and enzyme inhibition.

Unit 7: Nitrogen metabolism (4 lectures)
Biological nitrogen fixation; Nitrate and ammonia assimilation.

Unit 8: Plant growth regulators (6 lectures)
Discovery and physiological roles of auxins, gibberellins, cytokinins, ABA, ethylene.

Unit 9: Plant response to light and temperature (6 lectures)
Photoperiodism (SDP, LDP, Day neutral plants); Phytochrome (discovery and structure), red and far red light responses on photomorphogenesis; Vernalization.

6.6. GE-4 P6: Plant Physiology & Metabolism

(Practical: Marks 15/Credits 2)

1. Determination of osmotic potential of plant cell sap by plasmolytic method.
2. To study the effect of two environmental factors (light and humidity) on transpiration by excised twig.
3. Calculation of stomatal index and stomatal frequency of a mesophyte and a xerophyte.
4. To study the effect of light intensity and bicarbonate concentration on O2 evolution in photosynthesis.
5. Comparison of the rate of respiration in any two parts of a plant.

Demonstration experiments (any four)
1. Bolting; 2. Effect of auxins on rooting; 3. Suction due to transpiration; 4. R.Q.; 5. Respiration in roots.

Suggested Readings

1. Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development. Sinauer Associates Inc. USA. 6th edition.
2. Hopkins, W.G., Huner, N.P., (2009). Introduction to Plant Physiology. John Wiley & Sons, U.S.A. 4th Edition.
3. Bajracharya, D., (1999). Experiments in Plant Physiology- A Laboratory Manual. Narosa Publishing House, New Delhi.

6.7. GE-4 T7: Economic Botany & Plant Biotechnology
Course Code: SH/BOT/404/GE-4

(Theory: Lecture 60/Credits 4/Marks 25)

Economic Botany (Marks-15)

Unit 1: Origin of Cultivated Plants (4 lectures)
Concept of centres of origin, their importance with reference to Vavilov's work.

Unit 2: Cereals (4 lectures)
Wheat - Origin, morphology, uses.

Unit 3: Legumes (6 lectures)
General account with special reference to Gram and soybean.

Unit 4: Spices (6 lectures)
General account with special reference to clove and black pepper (Botanical name, family, part used, morphology and uses).

Unit 5: Beverages (4 lectures)
Tea (morphology, processing, uses).

Unit 6: Oils and Fats (4 lectures)
General description with special reference to groundnut.

Unit 7: Fibre Yielding Plants (4 lectures)
General description with special reference to Cotton (Botanical name, family, part used, morphology and uses).

Plant Biotechnology (Marks-10)

Unit 8: Introduction to biotechnology (2 lecture)

U nit 9: Plant tissue culture (8 lectures)
Micropropagation; haploid production through androgenesis and gynogenesis; brief account of embryo and endosperm culture with their applications.

Unit 10: Recombinant DNA Techniques (18 lectures)
Blotting techniques: Northern, Southern and Western Blotting, DNA Fingerprinting; Molecular DNA markers i.e. RAPD, RFLP, SNPs; DNA sequencing, PCR and Reverse Transcriptase-PCR. Hybridoma and monoclonal antibodies, ELISA and Immunodetection. Molecular diagnosis of human disease, Human gene Therapy.

6.7. GE-4 P7: Economic Botany & Plant Biotechnology

(Practical: Marks 15/Credits 2)

1. Study of economically important plants: Wheat, Gram, Soybean, Black pepper, Clove Tea, Cotton, Groundnut through specimens, sections and microchemical tests
2. Familiarization with basic equipments in tissue culture.
3. Study through photographs: Anther culture, somatic embryogenesis, endosperm and embryo culture; micropropagation.
4. Study of molecular techniques: PCR, Blotting techniques, AGE and PAGE.

Suggested Readings

1. Kochhar, S.L. (2011). Economic Botany in the Tropics, MacMillan Publishers India Ltd., New Delhi. 4th edition.
2. Bhojwani, S.S. and Razdan, M.K., (1996). Plant Tissue Culture: Theory and Practice. Elsevier Science Amsterdam. The Netherlands.
3. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.

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