



Bachelor of Science (Honours) Botany under CBCS

PATNA UNIVERSITY, PATNA

Programme Code:

Programme Outcomes

At the completion of the programme, students will attain the ability to:

PO1: Provide thorough knowledge about various plant groups from primitive to highly evolved

PO2: Equip the students with skills related to laboratory as well as field-based studies

PO3: Make the students and people aware about the conservation and sustainable use of plants as well as to address the socio-economic challenges related to plant sciences

PO4: Knowledge of inter religious studies to decipher the rich cultural heritage of our country and values

PO5: Highlight the potential of these students to become an entrepreneur as per start up and make in India scheme

Programme Specific Outcomes

At the completion of the programme, students will attain the ability to:

PSO1: Taxonomic studies will help in exploration of flora.

PSO2: Microbiology and plant diseases will enable to know about the various microbes and plant diseases, respectively along with their control.

PSO3: Laboratory works will provide knowledge of various techniques and scientific equipment efficiently.

PSO4: Study of Basic Genetics will have the way of deciphering complex modern Biology.

PSO5: Development of awareness about the type of pollution and their control.

PSO6: Study of RDT, Molecular Biology, Biotechnology and others will help in developing genetically engineered crops, protecting endangered plants and large scale production of different vaccines including the very recently developed Corona-19 vaccine too.

Course Structure

Sl. No.	Course Code	Name of the Course	Type of Course	L-T-P	Credit	Marks
1		Phycology and Microbiology (Th)	CC-1 (Th)	4-1-0	4	100
2		Phycology and Microbiology (P)	CC-1 (P)	0-0-6	2	100
3		Biomolecules and Cell Biology (Th)	CC-2 (Th)	4-1-0	4	100
4		Biomolecules and Cell Biology (P)	CC-2 (P)	0-0-6	2	100
5		English Communication/MIL	AECC- 1	2-1-0	2	100
6		Generic Elective- 1 (Th)	GE- 1 (Th)	4-1-0	4	100
7		Generic Elective- 1 (P)	GE- 1 (P)	0-0-6	2	100
Total credit - 20						

Sl. No.	Course Code	Name of the Course	Type of Course	L-T-P	Credit	Marks
1		Mycology and Phytopathology (Th)	CC-3 (Th)	4-1-0	4	100
2		Mycology and Phytopathology (P)	CC-3 (P)	0-0-6	2	100
3		Archegoniate (Th)	CC-4 (Th)	4-1-0	4	100
4		Archegoniate (P)	CC-4 (P)	0-0-6	2	100
5		Environmental Science	AECC- 2	2-1-0	2	100
6		Generic Elective- 2 (Th)	GE- 2 (Th)	4-1-0	4	100
7		Generic Elective- 2 (P)	GE- 2 (P)	0-0-6	2	100
Total credit - 20						

Semester –III

Sl. No.	Course Code	Name of the Course	Type of Course	L-T-P	Credit	Marks
1		Morphology and Anatomy (Th)	CC-5 (Th)	4-1-0	4	100
2		Morphology and Anatomy (P)	CC-5 (P)	0-0-4	2	100
3		Economic Botany (Th)	CC-6 (Th)	4-1-0	4	100
4		Economic Botany (P)	CC-6 (P)	0-0-4	2	100
5		Genetics (Th)	CC-7 (Th)	4-1-0	4	100
6		Genetics (P)	CC-7 (P)	0-0-4	2	100
7		Skill Enhancement Course- 1	SEC- 1	2-0-0	2	100
8		Generic Elective- 3 (Th)	GE- 3 (Th)	4-1-0	4	100
9		Generic Elective- 3 (P)	GE- 3 (P)	0-0-4	2	100
Total credit - 26						

Semester –IV

Sl. No.	Course Code	Name of the Course	Type of Course	L-T-P	Credit	Marks
1		Molecular Biology (Th)	CC-8 (Th)	4-1-0	4	100
2		Molecular Biology (P)	CC-8 (P)	0-0-4	2	100
3		Plant Ecology and Phytogeography (Th)	CC-9 (Th)	4-1-0	4	100
4		Plant Ecology and Phytogeography (P)	CC-9 (P)	0-0-4	2	100
5		Plant Systematics (Th)	CC-10 (Th)	4-1-0	4	100
6		Plant Systematics (P)	CC-10 (P)	0-0-4	2	100
7		Skill Enhancement Course- 2	SEC- 2	2-0-0	2	100
8		Generic Elective- 4 (Th)	GE- 4 (Th)	4-1-0	4	100
9		Generic Elective- 4 (P)	GE- 4 (P)	0-0-4	2	100
Total credit - 26						

Semester – V

Sl. No.	Course Code	Name of the Course	Type of Course	L-T-P	Credit	Marks
1		Reproductive Biology of Angiosperms (Th)	CC-11 (Th)	4-1-0	4	100
2		Reproductive Biology of Angiosperms (P)	CC-11 (P)	0-0-4	2	100
3		Plant Physiology (Th)	CC-12 (Th)	4-1-0	4	100
4		Plant Physiology (P)	CC-12 (P)	0-0-4	2	100
5		Discipline Specific Elective- 1 (Th)	DSE- 1 (Th)	4-1-0	4	100
6		Discipline Specific Elective- 1 (P)	DSE- 1 (P)	0-0-4	2	100
7		Discipline Specific Elective- 2 (Th)	DSE- 2 (Th)	4-1-0	4	100
8		Discipline Specific Elective- 2 (P)	DSE- 2 (P)	0-0-4	2	100
Total credit - 24						

Semester – VI

Sl. No.	Course Code	Name of the Course	Type of Course	L-T-P	Credit	Marks
1		Plant Metabolism (Th)	CC-13 (Th)	4-1-0	4	100
2		Plant Metabolism (P)	CC-13 (P)	0-0-4	2	100
3		Recombinant DNA Technology & Plant Biotechnology (Th)	CC-14 (Th)	4-1-0	4	100
4		Recombinant DNA Technology & Plant Biotechnology (P)	CC-14 (P)	0-0-4	2	100
5		Discipline Specific Elective- 3 (Th)	DSE- 3 (Th)	4-1-0	4	100
6		Discipline Specific Elective- 3 (P)	DSE- 3 (P)	0-0-4	2	100
7		Discipline Specific Elective- 4 (Project/Dissertation)	DSE- 4	0-0-6	6	100
Total credit - 24						

*L/T/P: number of classes per week

DSE/GE may either carry 6 credit, i.e., Theory (4 credit) + Practical (2 credit) format

Or

Consolidated (6 credit) for Theory only

Discipline Specific Elective Course (DSE):

Course name	L-T-P
<ol style="list-style-type: none">1. Plant Breeding2. Biostatistics3. Research Methodology4. Industrial and Environmental Biology5. Phytochemistry and Uses of Medicinal Plants6. Horticultural practices and Post Harvest Management Technology7. Project/ Dissertation	

Generic Elective (GE):

For Botany Students		For Other Students	
Course name	L-T-P	Course name	L-T-P
		<ol style="list-style-type: none">1. Biodiversity and conservation2. Food Processing3. Plant Biotechnology4. Environmental Biotechnology5. Herbal Technology6. Biomolecules7. Nanoscience8. Radioactive elements and its Application	

Skill Enhancement courses (SEC):

1. Applied Phycology, Mycology and Microbiology
2. Biofertilizers
3. Plant breeding culture
4. Mushroom Culture Technology
5. Instrumental Biology
6. Artificial Intelligence and their Application
7. Herbal Technology
8. Floriculture
9. Plant Diversity and Human Welfare
10. Intellectual Property Rights
11. IT tools of Science

SEMESTER - I

CC1: Phycology and Microbiology

Course Outcomes

After the completion of the course, the students will be able to:

- CO1:** Classify the plant kingdom
CO2: Describe the diversity, structure and importance of viruses and bacteria
CO3: Describe the general account of mycoplasma and diseases caused by them
CO4: Explain the thallus organization, economic importance and the life cycle of various algae

CC1 Phycology and Microbiology (Theory: 4 credits)		
Unit	Topics to be covered	No. of Lectures
1	Classification of Plant Kingdoms and their important features (Whittaker 1969)	04
2	Virus- Discovery, General structure, DNA virus (T-phage); replication (Lytic and lysogenic Cycle), RNA virus- TMV; Economic importance of viruses, Coronavirus (elementary idea)	10
3	Bacteria – Discovery, General characteristics, types- archaebacteria and eubacteria, Reproduction-vegetative, asexual and genetic recombination (conjugation, transformation and transduction); Economic importance of bacteria with reference to their role in agriculture and industry (N ₂ fixation, fermentation and medicine) General account of Mycoplasma and diseases caused by them	16
4	Algae- General characteristics; Classification; Range of thallus organization and reproduction; Significant contributions of important Psychologists (F.E. Fritsch, G.M. Smith, R.N. Singh, T.V. Desikachary, H.D. Kumar, M.O.P. Iyengar); Structure, Life	18

	history, and Affinities of the following genera: <i>Nostoc</i> , <i>Volvox</i> , <i>Oedogonium</i> , <i>Chara</i> , <i>Vaucheria</i> , <i>Batrachospermum</i> and <i>Ectocarpus</i> ; Economic Importance of Algae	
	TOTAL	48

Suggested Readings :

1. Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.
2. Prescott, L.M., Harley J.P., Klein D. A. (2005). Microbiology, McGraw Hill, India. 6th edition
3. Kumar, H.D. (1999). Introductory Phycology. Affiliated East-West Press, Delhi.
4. 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.
5. Pelczar, M.J. (2001) Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.
6. Vashishtha, B.R., Sinha, A.K. Singh, V.P. (2010). Botany for degree students: Algae, S. Chand & Company Ltd. 2nd edition
7. Srivastava, H.N. (2005). Algae, Pradeep Publication. 12th edition.
8. Dubey R.C., Maheshwari D.K. (2005). A Text Book of Microbiology, S. Chand & Company Ltd. 2nd edition.

CC1	Phycology and Microbiology (Practical: 2 credit)
Practical	
<ol style="list-style-type: none"> 1. Electron micrographs/Models of viruses – T-Phage and TMV 2. Line drawings/ Photographs of Lytic and Lysogenic Cycle 3. Types of Bacteria to be observed from photographs 4. Gram staining of bacteria. 5. Phycology: Study of vegetative and reproductive structures of the forms prescribed in the syllabus through temporary and permanent slides preparations. 	

CC2: Biomolecules and Cell Biology

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Describe the structure and properties of biomolecules
CO2: Explain the classification, properties and functions of enzymes
CO3: Describe cell wall, cell membrane and the structure, chemistry and functions of cellular organelles
CO4: Explain the eukaryotic cell cycle, mitotic and meiotic cell divisions; and regulation of cell cycle

CC2		
Biomolecules and Cell Biology (Theory: 4 credits)		
Unit	Topics to be covered	No. of Lectures
1	Biomolecules: Carbohydrates, amino acids, proteins, lipids, nucleotides and nucleic acid	14
2	Enzymes: Classification, nomenclature, physico-chemical properties, mechanism of action and regulation	12

3	Cell: Cell theory, Characteristics of prokaryotic and eukaryotic cells; Origin of eukaryotic cell (Endosymbiotic theory); Cell wall and Cell membrane, structure and function of cell organelles: nucleus (including nucleolus and chromatin), mitochondria, ribosomes, golgi apparatus, endoplasmic reticulum, lysosomes, plastids and vacuoles	16
4	Cell division: Mitosis and meiosis; cell cycle and its regulation	06
	TOTAL	48

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.
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.

CC2	Biomolecules and Cell Biology (Practical: 2 credits)
Practical	
<ol style="list-style-type: none"> 1. Estimation of organic acid and fatty acid by titration 2. Estimation of protein and sugar by spectrophotometry 3. Detection of tannin, alkaloid and flavonoid in the given plant sample 4. Separation of amino acids by paper chromatography technique 5. Study of cell and its organelles with the help of electron micrographs 6. Study different stages of mitosis and meiosis 	

SEMESTER- II

CC3: Mycology and Phytopathology

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Describe the thallus organization, nutrition, economic importance and life cycle of various fungi
- CO2:** Explain the diversity, structure and importance of lichen and mycorrhiza
- CO3:** Describe the terms, scope and importance of plant pathology
- CO4:** Describe the etiology, symptoms and control measures of plant diseases

CC3 Mycology and Phytopathology (4 credits)		
Unit	Topics to be covered	No. of Lectures
1	Fungi: General characteristics; Thallus organization; Nutrition; Cell wall composition; Reproduction and Classification General account of Lichens, types & economic importance; Mycorrhiza-Ectomycorrhiza, Endomycorrhiza and their significance	12
2	Structure and life history of the following genera: <i>Synchytrium</i> , <i>Rhizopus</i> , <i>Peziza</i> , <i>Albugo</i> , <i>Alternaria</i> and <i>Puccinia</i>	10
3	Phytopathology: Terms and concepts; General symptoms; Geographical distribution of diseases; etiology; Host- Pathogen relationships; disease cycle; prevention and control of plant diseases	12
4	Etiology, symptoms and control of the following diseases: Citrus canker, Little leaf of brinjal, Wart disease of potato, Early and Late blight of potato, Black stem rust of wheat and White rust of crucifers, Red rot of sugarcane	14
	TOTAL	48

Suggested Readings :

- Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley & Sons (Asia) Singapore. 4th edition.
- Webster, J. and Weber, R. (2007). Introduction to Fungi, Cambridge University Press, Cambridge. 3rd edition.
- Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, Macmillan Publishers India Ltd.
- Sharma, P.D. (2011). Plant Pathology, Rastogi Publication, Meerut, India.
- Vashishtha, B.R. Sinha, A.K. (2005). Botany for degree Students Part II, S. Chand & Company Ltd. 2nd edition.
- Bilgrami, K.S. Dubey, H.C. (2005). A text book of Modern Plant Pathology, Vikas Publishing Home Pvt. Ltd. 2nd edition.

CC3 Mycology and Phytopathology (Practical: 2 credits)	
Practical :	
<ol style="list-style-type: none"> Mycology: Study of vegetative and reproductive structures of <i>Rhizopus</i> and <i>Peziza</i> (ascocarp) through temporary preparations and permanent slides Lichen: Study of growth forms of lichens (crustose, foliose and fruticose) on different substrates (Photographs); Mycorrhizae: ectomycorrhizal and endomycorrhiza (Photographs) Phytopathology: Study of Host-parasite relationship of <i>Synchytrium</i>, <i>Albugo</i>, <i>Alternaria</i> and <i>Puccinia</i> through temporary preparations and permanent slides Photographs of fungal spores Herbarium specimens/ Photographs of Citrus Canker; TMV, Early blight of potato, Black stem rust of wheat and White rust of crucifers 	

CC4: Archegoniate

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Explain the morphological diversity and evolution of bryophytes, pteridophytes and gymnosperms
- CO2:** Compare the life cycle of various bryophytes, pteridophytes and gymnosperms
- CO3:** Describe the economic importance of the bryophytes, pteridophytes and gymnosperms
- CO4:** Describe fossil pteridophytes (*Rhynia* and *Calamites*)

CC4 Archegoniate (Theory: 4 credits)		
Unit	Topics to be covered	No. of Lectures
1	Introduction: Distinguishing features of archegoniates; transition to land habit; alternation of generations	02
2	Bryophytes: General Characteristics, Adaptation to land habit, Classification (up to family); Vegetative reproduction; Range of thallus organization; Structure, life history & affinities of the following genera- <i>Marchantia</i> , <i>Anthoceros</i> , <i>Sphagnum</i> and <i>Funaria</i> ; Ecological and economic importance of bryophytes	14
3	Pteridophytes: General characteristics, classification (up to family), telome theory, stellar evolution, apogamy and apospory, morphology, anatomy and reproduction of <i>Psilotum</i> , <i>Selaginella</i> with special reference to seed habit, <i>Equisetum</i> and <i>Marsilea</i> ; Ecological and economic importance; Fossil Pteridophytes – <i>Rhynia</i> & <i>Calamites</i>	16
4	Gymnosperm: General characteristics, classification (up to family), morphology, anatomy and reproduction of <i>Cycas</i> , <i>Pinus</i> and <i>Gnetum</i> ; Ecological and economic importance	16
TOTAL		48

Suggested Readings :

1. Vander-Poorteri 2009 Introduction to Bryophytes, COP.
2. Vashistha, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta, S. Chand. Delhi, India.
3. Bhatnagar, S.P. & Moitra, A. (1996). Gymnosperms, New Age International (P) Ltd Publishers, New Delhi, India.
4. Vashistha, P.C., Sinha, A.K. Kumar, A. (2006). Botany for degree students: Gymnosperm, S. Chand & Company Pvt. Ltd.
5. Srivastava, H.N. (2002). Gymnosperm, Pradeep Publications. 10th edition.
6. Rashid A. (1999). An introduction to Pteridophyta Vikas Publishing Home Pvt. Ltd. 2nd edition.
7. Puri P. (1996). Bryophyta: Morphology, Growth and Differentiation, Atma Ram and Sons, 2nd edition..

CC4 Archegoniate (Practical: 2 credits)
Practical :
<ol style="list-style-type: none"> 1. Bryophytes: Study of vegetative and reproductive structures of <i>Marchantia</i>, <i>Anthoceros</i>, <i>Sphagnum</i> and <i>Funaria</i> through temporary preparations and permanent slides 2. Pteridophytes: Study of vegetative and reproductive structures of <i>Psilotum</i>, <i>Selaginella</i>, <i>Equisetum</i> and <i>Marsilea</i> through temporary preparations and permanent slides 3. Gymnosperms: Study of vegetative and reproductive structures of <i>Cycas</i>, <i>Pinus</i> and <i>Gnetum</i> through temporary preparations and permanent slides

SEMESTER – III

CC5: Anatomy of Angiosperms

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Explain the tissue system in plants and their functions
- CO2:** Understand the normal and anomalous secondary growth in plants and their causes
- CO3:** Learn about the structural adaptations in plants growing in different environmental conditions
- CO4:** Describe the structure and function of periderm

CC5 Anatomy of Angiosperms (Theory: 4 credits)		
Unit	Topics to be covered	No. of Lectures
1	Meristem and permanent tissue; Root and shoot meristem, simple and complex tissue Mechanical Tissues – Structure, distribution and function	16
2	Normal secondary growth; Anomalous secondary growth in <i>Tinospora</i> , <i>Bignonia</i> , <i>Boerhaavia</i> , and <i>Dracaena</i>	14
3	Organization of tissue in relation to environment: Hydrophytes, Xerophytes, Halophytes and Epiphytes	14
4	Periderm – Origin, structure and function	04
	TOTAL	48

Suggested Readings :

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 Benjamin/Cummings Publisher, USA.
4. Esau, K. (1977). Anatomy of Seed Plants, John Wiley & Sons, Inc., Delhi.
5. Vasishtha, P.C. (2004). Plant Anatomy, Pradeep Publication. 17th edition.
6. Grewal, R.C. (2011). Plant Anatomy, Campus Book International. 1st edition.
7. Singh S.K. Srivastava. S. (2014). Anatomy of angiosperms, Campus Books International. 1st edition.

CC5 Anatomy of Angiosperms (Practical: 2 credits)
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Practical

1. Study of anatomical details through permanent slides/temporary stain mounts/ Photographs
2. Distribution and types of parenchyma, collenchyma and sclerenchyma through permanent slides/temporary stain mounts/ Photographs
3. Study of anomalous secondary growth in *Tinospora*, *Bignonia*, *Boerhaavia*, and *Dracaena* through temporary preparations and permanent slides
4. Study of morphological and anatomical adaptations in hydrophytes and xerophytes through specimens and temporary slide preparations

CC6: Economic Botany**Course Outcomes**

After the completion of the course, the student will be able to:

- CO1:** Create awareness about plants of economic importance
CO2: Know about their distribution patterns
CO3: Identify them on the basis of their botanical features
CO4: Learn about their cultivation and economic importance

CC6_ Economic Botany (Theory: 4 credits)		
Unit	Topics to be covered	No. of Lectures
1	Botanical characteristics, cultivation, processing and uses of Cereals, Legumes, Oil and Fats	12
2	Botanical characteristics, cultivation, processing and uses of Spices, Fruits and Vegetables	12
3	Botanical characteristics, cultivation, processing and uses of Beverages, Narcotics, Timber and Fiber yielding plant	12
4	Botanical characteristics, cultivation, processing and uses of Medicinal plants, Sugar and Starch yielding plants	12
	TOTAL	48

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. (2003). Plants, Genes and Agriculture, Jones & Bartlett Publishers.
4. Pandey, B.P. (2005). Economic Botany, S. Chand & Company Pvt. Ltd. 6th edition.
5. Kochner, S.N. (2016). Economic Botany: A Comprehensive Study, Cambridge University Press. 5th edition.
6. Sharma, V. K., Shenai, S. K. (2013). Economically Important Medicinal Plants, Campus Book International. 1st edition.
7. Arya, P.S. (2000). Spice Crops of India, Kalyani Publishers.

CC6_ Economic Botany

(Practical: 2 credits)

Practical :

Study of botanical characteristics, cultivation, processing and uses of Cereals, Legumes, Oil & fats, Spices, Fruits and vegetables, Beverages, Narcotics, Timber and Fibre yielding plant, Medicinal plants, Sugar and starch yielding plants

CC7: Basics of Genetics

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Understand Mendelian laws of inheritance and its variations
- CO2:** Comprehend the effect of chromosomal abnormalities leading to genetic disorders
- CO3:** Know the details of mutations and their uses
- CO4:** Know about the sex determination and sex linked inheritance

CC7 Basics of Genetics (Theory: 4 credits)		
Unit	Topics to be covered	No. of Lectures
1	Mendelian inheritance: Mendel's experiments and principles of inheritance: back cross and test cross; gene interactions and modified dihybrid ratio-complementary, supplementary, duplicate and epistatic factor and inhibitory genes	14
2	Linkage and crossing over: Cytological basis of crossing over; Recombination frequency, two factor and three factor crosses; Interference and coincidence; Sex determination and sex linked inheritance; Cytoplasmic inheritance	14
3	Mutations: Types and induction (physical and chemical mutagens); Molecular basis of mutations and their role	08
4	Chromosomes: Physical and chemical characteristics, Lampbrush chromosomes, B-chromosomes and polytene chromosomes;	12

	Chromosomal aberrations: Deletion, Duplication, Inversion, Translocation, Position effect, Euploidy and Aneuploidy, Polyploidy (types and role in evolution)	
	TOTAL	48

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. Klug, W.S., Cummings, M.R., Spencer, C.A. (2012). Concepts of Genetics, Benjamin Cummings, U.S.A. 10th edition.
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. Verma, P.S. Agarwal, V.K. (2010). Genetics, S. Chand & Company Pvt. Ltd. 2nd edition.
6. Singh, B.D. (2014). Genetics, Kalyani Publishers. 2nd edition.
7. Gupta P.K. (2001). Genetics, Rastogi Publication. 3rd edition.

CC7	Basics of Genetics (Practical: 2 credits)
Practical	<ol style="list-style-type: none"> 1. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square analysis 2. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 9:3:4, 12:3:1, 13:3, 15:1)

SEMESTER – IV

CC8: Molecular Biology

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Decipher the structures and chemical properties of DNA and RNA and their role
- CO2:** Gain an understanding of various steps in transcription and translation in prokaryotes and eukaryotes
- CO3:** Know about gene regulation in prokaryotes and eukaryotes
- CO4:** Gain knowledge of modern biology techniques

CC8	Molecular Biology (Theory: 4 credits)
Unit	Topics to be covered
	No. of Lectures

1	Nucleic acids, structures of DNA and RNA, forms of DNA, DNA replication and role of DNA polymerases, different forms of RNA and their role, Genetic code	16
2	Central dogma, Transcription and Translation in prokaryotes and eukaryotes	12
3	Gene regulation in prokaryotes (Lac operon) and eukaryotes	10
4	Blotting techniques: northern, southern & western blotting, DNA fingerprinting, Gel Electrophoresis, Polymerase Chain Reaction	10
	TOTAL	48

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). iGenetics- A Molecular Approach. Benjamin Cummings, U.S.A. 3rd edition.
5. Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis, W. H. Freeman and Co., U.S.A. 10th edition.
6. Channarayappa (215). Molecular Biology, Universities Press. 1st edition.
7. Karp Gerald (2010). Cell Biology, John Willey and Sons., Inc. 6th edition

CC8	Molecular Biology (Practical: 2 credits)
Practical	
<ol style="list-style-type: none"> 1. DNA isolation from cauliflower head 2. DNA estimation by diphenylamine reagent/UV Spectrophotometry 3. Study of DNA replication mechanisms through photographs 4. Study of structures of prokaryotic RNA polymerase and eukaryotic RNA polymerase II through photographs 	

CC9: Plant Ecology and Phytogeography

Course Outcomes

After the completion of the course, the student will have to:

- CO1:** Knowledge of plant communities and ecological adaptations in plants
- CO2:** Knowledge about the soils on the basis of physical, chemical and biological components
- CO3:** Know about the types of pollution and their control measures
- CO4:** Knowledge about the conservation of biodiversity, types and control of pollution phyto geographical regions of India and non-conventional energy

CC9 Plant Ecology and Phytogeography (Theory: 4 credits)		
Unit	Topics to be covered	No. of Lectures
1	Environment, Ecology, Biosphere, Biome, habitat, niche; Adaptation of hydrophytes and xerophytes Biotic interactions: Beneficial and harmful interactions (symbiosis, commensalism, amensalism, herbivory, predation, parasitism)	06
2	Population ecology: Characteristics and Regulations Community ecology: Concept of ecological amplitude; Characters: analytical and synthetic; Ecotone and edge effect; Dynamics: succession (Hydrosere and Xerosere) Ecosystem: Structure and function of ecosystem, food chains and webs, Principles and models of energy flow, ecological pyramids	10
3	Soil: Origin, Formation, Composition (Physical, Chemical and Biological) Soil profile and importance Water: Precipitation types (rain, fog, snow, hail, dew), Soil water and Water table	16
4	Biogeochemical cycles: Gaseous and sedimentary cycles, Hydrological cycle Environmental pollution: Air pollution, water pollution, noise pollution, radioactive pollution and their control measures, global Warming and Ozone hole Phytogeography: Major vegetational belts of India	16
TOTAL		48

Suggested Readings :

1. Odum, E.P. (2005). Fundamentals of ecology, Cengage Learning India Pvt. Ltd., New Delhi. 5th edition.
2. Singh, J.S., Singh, S.P., Gupta, S. (2006). Ecology Environment and Resource Conservation, Anamaya Publications, New Delhi, India.
3. Sharma, P.D. (2010). Ecology and Environment, Rastogi Publications, Meerut, India. 8th edition.
4. Wilkinson, D.M. (2007). Fundamental Processes in Ecology: An Earth Systems Approach, Oxford University Press. U.S.A.
5. Kormondy, E.J. (1996). Concepts of ecology, PHI Learning Pvt. Ltd., Delhi, India. 4th edition.
6. Dash, M.C., Dash, S.P. (2009). Fundamentals of Ecology, Tata McGraw Hill. 3rd edition.
7. Shukla, R.S., Chandel, P.S. (2010). A text book of Plant Ecology, S. Chand & Company Pvt. Ltd. 2nd edition.

CC9 Plant Ecology and Phytogeography (Practical: 2 credits)	
Practical :	
<ol style="list-style-type: none"> 1. Determination of pH of various soil and water samples 2. Analysis for carbonates, chlorides, nitrates, sulphates, organic matter and base deficiency from two soil samples by rapid soil tests 3. Study of morphological adaptations of hydrophytes and xerophytes (four each) 4. Study of biotic interactions of the following: Stem parasite (<i>Cuscuta</i>), Root parasite (<i>Orobanche</i>) Epiphytes, Predation (Insectivorous plants) through specimens/ photographs 5. Quantitative analysis of herbaceous vegetation in the college campus for frequency and comparison with Raunkiaer's frequency distribution law 6. Quantitative analysis of herbaceous vegetation for density and abundance in the college campus Field visit 	

CC10: Plant Systematics

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Identify and classify the local flora
- CO2:** Know about the rules of ICBN
- CO3:** Awareness of different systems of Plant Classification
- CO4:** Preparation of herbarium and its importance

CC10 Plant Systematics (Theory: 4 credits)		
Unit	Topics to be covered	No. of Lectures
1	Systematics, Concept of taxa (family, genus, species); Categories and taxonomic hierarchy; Species concept (taxonomic, biological, evolutionary) Botanical nomenclature: Idea about important rules of plant nomenclature as per ICBN	18
2	Classification of plants as proposed by Bentham & Hooker and Hutchinson	10
3	Floral characteristics and economic importance of following families: Ranunculaceae, Asclepiadaceae, Apocynaceae, Amaranthaceae, Euphorbiaceae, Lamiaceae, Cyperaceae and Poaceae	10
4	Phylogeny of Angiosperms: Terms and concepts of primitive and advanced, homology and analogy, origin & evolution of angiosperms, methods of illustrating evolutionary relationship (phylogenetic tree, cladogram)	10
TOTAL		48

Suggested Readings :

1. Singh, G. (2012). Plant Systematics: Theory and Practice, Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition.
2. Jeffrey, C. (1982). An Introduction to Plant Taxonomy, Cambridge University Press, Cambridge.
3. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. (2002). Plant Systematics-A Phylogenetic Approach, Sinauer Associates Inc., U.S.A. 2nd edition.
4. Maheshwari, J.K. (1963). Flora of Delhi, CSIR, New Delhi.
5. Radford, A.E. (1986). Fundamentals of Plant Systematics, Harper and Row, New York.
6. Sharma, O.P. (2016). Plant Taxonomy, McGraw Hill Education Pvt. Ltd. 2nd edition.
7. Sambamurthy, A.V.S.S. (2005). Taxonomy of angiosperms, I.K. International Pvt. Ltd. 1st edition.

BOT CC10	Plant Systematics (Practical: 2 credits)
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Practical :

1. 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): Ranunculaceae-*Ranunculus*, Lamiaceae- *Ocimum sanctum*, Apocynaceae-*Vinca rosea*, Amaranthaceae- *Achyranthus aspera*, Asclepiadaceae- *Calotropis procera gigantea*
2. Preparation of Herbarium sheets (to be submitted in the record book)

SEMESTER – V**Reproductive Biology of Angiosperms****Course Outcomes**

After the completion of the course, the student will be able to:

- CO1:** Know about the reproductive biology of angiosperms
CO2: Understand structure and functions of anther wall and pollen wall, pollen biology
CO3: Learn detailed study of structure of pistil, megasporangium, double fertilization and endosperm
CO4: Comprehend the causes of Polyembryony and apomixis with its classification

CC11 Reproductive Biology of Angiosperms (Theory: 4 credits)		
Unit	Topics to be covered	No. of Lectures
1	Anther: Structure and functions of anther wall, microsporogenesis, callose deposition and its significance Pollen biology: Microgametogenesis; Pollen wall structure, MGU (male germ unit) structure, NPC system; Palynology and scope (a brief account); Pollen viability, germination; Abnormal features: Pseudomonads, polyads, massulae, pollinia	14
2	Ovule: Structure; Types; Special structures–endothelium, obturator, aril, caruncle and hypostase; Female Gametophyte (Types of Embryo sacs) and megagametogenesis (details of <i>Polygonum</i> type); Organization and ultrastructure of mature embryo sac Pollination and Fertilization: Pollination types and significance; adaptations; structure of stigma and style; sexual incompatibility, path of pollen tube in pistil; double fertilization Endosperm: Types, development and structure	20
3	Embryo: General pattern of development of dicot and monocot embryo; Suspensor: structure and functions; Embryo-endosperm relationship; Nutrition of embryo	08
4	Apomixis & Polyembryony – Definition, types and applications	06
TOTAL		48

Suggested Readings :

1. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms, Vikas Publishing 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. I (1984). Embryology of Angiosperms, Springer-Verlag, Netherlands.
5. Johri, B.N. Ambegaokar, K.B., Srivastava, P.S. (2015). Comparative Embryology of Angiosperms, Vol. 1 & 2. Springer. 1st edition.

CC11	Reproductive Biology of Angiosperms (Practical: 2 credits)
Practical :	
<ol style="list-style-type: none"> 1. Photographs of pollen grains of families: Malvaceae, Liliaceae, Asteraceae, Poaceae 2. Study of anther, ovule, double fertilization, endosperm and embryo through photographs/ ppt 3. Models of the above topics to be submitted by the students 	

CC12: Plant Physiology**Course Outcomes****After the completion of the course, the student will be able to:**

- CO1:** Understand Water relation of plants with respect to various physiological processes
- CO2:** Know about the mineral nutrition
- CO3:** Classify aerobic and anaerobic respiration, significance of respiration and photosynthesis
- CO4:** Understand dormancy and germination in plants; learn about types and roles of phytohormones

CC12	Plant Physiology (Theory: 4 credits)	
Unit	Topics to be covered	No. of Lectures
1	Plant water relationship: Imbibition, diffusion and osmosis; Water Potential and its components; Active and passive transport of water and solutes; Ascent of sap; Transpiration and factors affecting transpiration, mechanism of stomatal movement and factors controlling it Transport of organic substances, path of translocation, mechanism of translocation	16
2	Mineral nutrition: Macro and micronutrients and their role in plant nutrition; nutrient uptake and transport mechanisms. role of carriers	08
3	Phytohormones: Discovery, chemical nature (basic structure), bioassay and physiological roles of Auxin, Gibberellins, Cytokinin, Abscisic acid, Ethylene	12

4	Physiology of flowering: Photoperiodism and vernalization; Plant movements, plant growth	12
	TOTAL	48

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. Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual, Narosa Publishing House, New Delhi.
4. Jain V. K. (2014). Fundamentals of Plant Physiology, S. Chand & Company Ltd. 16th Revised edition
5. Verma V. (2016). Plant Physiology, Athena Academic. 2nd edition.
6. Mazumdar, B.C. (2005). Photoperiodism and Vernalization in Plants, Daya Publishing House. 1st edition.
7. Mukherji, S., Gosh, A.K. (1996). Plant Physiology, New Central Book Agency (P) Ltd. 1st edition.

CC12	Plant Physiology (Practical: 2 credits)
Practical :	
<ol style="list-style-type: none"> 1. Determination of the rate of transpiration by using Farmer's Potometer 2. Determination of the amount of water absorbed and transpired by a plant, using T/A apparatus 3. To compare the rate of imbibition of oily and starchy seeds 4. Study of effect of sugar concentrations on leaf cell by plasmolytic method 	
Demonstration experiments	
<ol style="list-style-type: none"> 1. Bell jar experiment 2. Demonstration of osmosis using potato 	

SEMESTER – VI

CC13: Plant Metabolism

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Understand the anabolic and catabolic pathways of metabolism
CO2: Recognize the importance of carbon assimilation in photorespiration
CO3: Understand ATP synthesis in respiration
CO4: Interpret the biological nitrogen fixation

CC13	Plant Metabolism (Theory: 4 credits)	
Unit	Topics to be covered	No. of Lectures

1	Concept of metabolism, regulation of metabolism, role of regulatory enzymes (allosteric, covalent modulation and isozymes)	06
2	Photosynthesis; photosynthetic apparatus, pigments, photochemical reactions, electron transport pathways in chloroplast membranes, photophosphorylation, Calvin Cycle, Crassulacean Acid Metabolism, Hatch & Slack pathway, factors affecting photosynthesis	16
3	Respiration: Glycolysis, TCA Cycle and its regulation, electron transport in Mitochondria, oxidative phosphorylation, Pentose Phosphate Pathway	16
4	Biological nitrogen fixation (examples of legumes and non-legumes); Physiology and biochemistry of nitrogen fixation	10
TOTAL		48

Suggested Readings :

- Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology, John Wiley and Sons. U. S.A. 4th edition.
- Taiz, L., Zeiger, E., Møller, I.M. and Murphy, A (2015). Plant Physiology and Development, Sinauer Associates Inc. USA. 6th edition.
- Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual, Narosa Publishing House, New Delhi.
- Jain V. K. (2014). Fundamentals of Plant Physiology, S. Chand & Company Ltd. 16th Revised edition.
- Verma V. (2016). Plant Physiology, Athena Academic. 2nd edition.
- Harborne, J.B. (1973). Phytochemical Methods, John Wiley & Sons. New York.
- Pathak, V.N., Khatri, N.K., Pathak, M. (2012). Fundamental of Plant Physiology, Agribios. 5th edition.

CC13	Plant Metabolism (Practical: 2 credits)
Practical	
<ol style="list-style-type: none"> Chemical separation of photosynthetic pigments by Paper Chromatographic Technique To study the effect of light intensity on the rate of photosynthesis To study the effect of carbon dioxide concentration on the rate of photosynthesis 	
Demonstration experiments	
<ol style="list-style-type: none"> Moll's half leaf experiment Demonstration of light-screen experiment 	

CC14: Recombinant DNA technology and Plant Biotechnology

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Have knowledge about the core enzymes involved in Recombinant DNA Technology
- CO2:** Have knowledge about the different steps of Recombinant DNA Technology
- CO3:** Understand the principle and basic protocols for Plant Tissue Culture and its application
- CO4:** Know about the role of rDNA and Plant Biotechnology as well as biosafety concerns of GMO

CC14 Recombinant DNA technology and Plant Biotechnology (Theory: 4 credits)		
Unit	Topics to be covered	No. of Lectures
1	rDNA technology: History; Major enzymes used: Restriction enzymes-types and cleavage pattern; DNA ligase- types and ligation process. Steps of Genetic engineering: Selection of cloning vectors- Plasmids (natural, pBR322), Phages, cosmid.	12
2	Passenger DNA: Different strategies used for isolation/synthesis of gene; Construction of genomic and cDNA libraries Construction of rDNA: Different strategies for construction of rDNA. Methods of DNA transfer in suitable host: electroporation, microinjection, particle gun method. Selection strategies: Different methods for selection of clone (antibiotic resistant markers, colony hybridization, immune-screening) Expression of foreign gene	14
3	Plant Tissue Culture: Basic aspect, totipotency, organogenesis, embryogenesis (somatic and zygotic), Role of plant tissue culture in growth, development and differentiation, anther culture and their applications micro-propagation Germplasm conservation, Cryopreservation	12
4	Application of Recombinant DNA technology: In medicine (Humulin) and Agriculture (Bt-cotton, FlavrSavr tomato, Golden rice). Biosafety concerns on GMO	10
	TOTAL	48

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. Singh, B.D. (2012). Biotechnology : Expanding Horizons, Kalyani Publishers, 4th edition.
4. Rana, S.V.S. (2010). Environmental Biotechnology, Rastogi Publication. 1st edition.
5. Dubey R.C. (2006). A text book of Biotechnology, S. Chand & Company Pvt. Ltd. 4th edition.
6. Trivedi, P.C. (2006). Plant Biotechnology, Perspectives and Prospects, Printer Publisher. 1st edition.

CC14_ Recombinant DNA technology and Plant Biotechnology (Practical: 2 credits)	
Practical	
<ol style="list-style-type: none"> 1. (a) Preparation of MS medium (b) Demonstration of <i>in vitro</i> sterilization and inoculation methods using leaf and nodal explants of tobacco, <i>Datura</i>, <i>Brassica</i> etc 2. Study of anther, embryo and endosperm culture, micropropagation, somatic embryogenesis & artificial seeds through photographs 3. Study of steps of genetic engineering for production of Bt cotton, Golden rice, Flavr Savr tomato through photographs 4. Models on the above mentioned topics to be submitted by the students 	

Generic Elective Papers (GE) (6 credits each)

Generic Elective (GE) Course: An elective course chosen generally from an unrelated discipline/subject, with an intention to seek exposure is called a Generic Elective.

P.S.: A core course offered in a discipline/subject may be treated as an elective by other discipline/ subject and vice versa and such electives may also be referred to as Generic Elective.

SEMESTER – I

GE1: Biodiversity (Microbes, Algae, Fungi and Archegoniate)

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Know about viruses and bacteria
- CO2:** Know about different stages of algae
- CO3:** Get the knowledge of fungi and its different types
- CO4:** Know the anatomy and reproduction of specified bryophytes, pteridophytes and gymnosperms along with their ecological and economical importance

GE1 Biodiversity (Microbes, Algae, Fungi and Archegoniate) (Theory: 4 credits)		
Unit	Topics to be covered	No. of Lectures
1	Microbes: Viruses – Discovery, general structure, DNA virus (T-phage); Replication (Lytic and lysogenic cycle); RNA virus (TMV); Economic importance Bacteria – Discovery, General characteristics and cell structure; Reproduction – vegetative, asexual and genetic recombination (conjugation, transformation and transduction); Economic importance	11
2	Algae: General characteristics; Range of thallus organization and Classification of algae; Morphology and life-cycles of the following: <i>Nostoc</i> , <i>Oedogonium</i> , <i>Ectocarpus</i> , <i>Batrachospermum</i> ; Economic importance of algae	11
3	Fungi: General characteristics, range of thallus organization, nutrition, reproduction and classification; Morphology and life cycle of <i>Peziza</i> and <i>Puccinia</i> ; Lichens: General account, reproduction and significance; Mycorrhiza: ectomycorrhiza and endomycorrhiza and their significance Bryophytes: General characteristics, adaptations to land habit, Range of thallus Organization; Classification (up to family), Morphology, anatomy and reproduction of <i>Marchantia</i> , and <i>Sphagnum</i>	12
4	Pteridophytes: General characteristics, Classification (up to family), Stellar evolution, morphology, anatomy and reproduction of <i>Selaginella</i> with special reference to seed habit, <i>Equisetum</i> and <i>Marsilea</i> Fossil Pteridophytes – <i>Rhynia</i> Gymnosperm: General characteristics, classification (up to family), morphology, anatomy and reproduction of <i>Cycas</i> and <i>Pinus</i> , Economic importance	14
	TOTAL	48

Suggested Readings :

1. Prescott, L.M., Harley J.P., Klein D. A. (2005). Microbiology, McGraw Hill, India. 6th edition.
2. Pelczar, M.J. (2001) Microbiology, 5th edition, Tata McGraw-Hill Co, New Delhi.
3. Lee, R.E. (2008). Phycology, Cambridge University Press, Cambridge. 4th edition.

4. Alexopoulos, C.J., Mims, C.W., Blackwell, M. (1996). Introductory Mycology, John Wiley & Sons (Asia) Singapore. 4th edition.
5. Vander-Poorteri (2009). Introduction to Bryophytes, COP.
6. Vashistha, P.C., Sinha, A.K., Kumar, A. (2010). Pteridophyta, S. Chand. Delhi, India.
7. Bhatnagar, S.P. & Moitra, A. (1996). Gymnosperms, New Age International (P) Ltd Publishers, New Delhi, India.

GE1	Biodiversity (Microbes, Algae, Fungi and Archegoniate) (Practical: 2 credits)
Practical :	
1. Study of vegetative and reproductive structures of algae, fungi, bryophytes, pteridophytes and gymnosperms specified in the syllabus through temporary preparations and permanent slides	
2. Models and microphotographs of viruses and bacteria	

SEMESTER – II

GE2: Plant Ecology and Taxonomy

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Comprehend the basic concepts of plant ecology and taxonomy and botanical nomenclature
- CO2:** Understand the characteristics of different plant communities
- CO3:** Know the structure and functions of eco-system
- CO4:** Be aware about environmental pollution

GE2		Plant Ecology and Taxonomy (Theory: 4 credits)
Unit	Topics to be covered	No. of Lectures
1	Introduction: Concept of Environment, Ecology, Biosphere, Biome, habitat, niche; Adaptation of hydrophytes and xerophytes Environmental pollution: Air pollution, water pollution, noise pollution, radioactive pollution and their control measures	16
2	Ecosystem: Structure and functions , food chains and webs, ecological pyramids Succession: Hydrosere and Xerosere	12
3	Introduction to plant taxonomy: Identification, Nomenclature; Taxonomic hierarchy and classification Botanical Nomenclature: Principles and rules (ICBN), binomial system	10
4	Classification: Types of classification-artificial, natural and phylogenetic; Bentham and Hooker (up to series), Hutchinson system of classification (up to series); A study of the diagnostic features and economic importance of following families: Apocynaceae, Amaranthaceae and Lamiaceae	10
TOTAL		48

Suggested Readings :

1. Odum, E.P. (2005). Fundamentals of ecology. Cengage Learning India Pvt. Ltd., New Delhi. 5th edition.
2. Sharma, P.D. (2010). Ecology and Environment. Rastogi Publications, Meerut, India. 8th edition.
3. Wilkinson, D.M. (2007). Fundamental Processes in Ecology: An Earth Systems Approach. Oxford University Press. U.S.A.
4. Kormondy, E.J. (1996). Concepts of ecology. PHI Learning Pvt. Ltd., Delhi, India. 4th edition.
5. Singh, G. (2012). Plant Systematics: Theory and Practice. Oxford & IBH Pvt. Ltd., New Delhi. 3rd edition.
6. Jeffrey, C. (1982). An Introduction to Plant Taxonomy. Cambridge University Press, Cambridge.
7. Judd, W.S., Campbell, C.S., Kellogg, E.A., Stevens, P.F. (2002). Plant Systematics- A Phylogenetic Approach. Sinauer Associates Inc., U.S.A. 2nd edition.
8. Radford, A.E. (1986). Fundamentals of Plant Systematics. Harper and Row, New York.

GE2	Plant Ecology and Taxonomy (Practical: 2 credits)
Practical :	
<ol style="list-style-type: none"> 1. Study of morphological and anatomical adaptations of hydrophytes and xerophytes 2. 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): Lamiaceae- <i>Ocimum sanctum</i>, Apocynaceae- <i>Vinca rosea</i>, Amaranthaceae- <i>Achyranthus aspera</i> 3. Preparation of Herbarium sheets (to be submitted in the record book) 	

SEMESTER – III**GE3: Plant Anatomy and Embryology****Course Outcomes**

After the completion of the course, the student will be able to:

- CO1:** Understand the fundamental concepts of plant anatomy and embryology
CO2: Learn about the structural adaptations in plants growing in different environmental conditions
CO3: Know about secondary growth in plants
CO4: Gain the knowledge of flower, pollination and fertilization

GE3	Plant Anatomy and Embryology (Theory: 4 credits)	
Unit	Topics to be covered	No. of Lectures
1	Meristem and permanent tissue; Root and shoot meristem, simple and complex tissue	08
2	General account of adaptations in xerophytes and hydrophytes (morphological and anatomical)	08

3	Normal secondary growth; Anomalous secondary growth in <i>Tinospora</i> , <i>Boerhaavia</i> , and <i>Dracaena</i>	10
4	Structure of development of anther and pollen grain; Structure and types of ovules; Types of embryo sacs, organization and ultrastructure of mature embryo sac Pollination mechanisms and adaptations; Double fertilization; Seed-structure appendages and dispersal mechanisms Endosperm types, structure and functions; Dicot and monocot embryo; Embryo endosperm relationship	22
	TOTAL	48

Suggested Readings :

1. Dickison, W.C. (2000). Integrative Plant Anatomy, Harcourt Academic Press, USA.
2. Fahh, A. (1974). Plant Anatomy, Pergmon Press, USA.
3. Mauseth, J.D. (1988). Plant Anatomy, The Benjamin/Cummings Publisher, USA.
4. Esau, K. (1977). Anatomy of Seed Plants, John Wiley & Sons, Inc., Delhi.
5. Bhojwani, S.S. and Bhatnagar, S.P. (2011). The Embryology of Angiosperms, Vikas Publishing House. Delhi. 5th edition.
6. Shivanna, K.R. (2003). Pollen Biology and Biotechnology, Oxford and IBH Publishing Co. Pvt. Ltd. Delhi.
7. Raghavan, V. (2000). Developmental Biology of Flowering plants, Springer, Netherlands.
8. Johri, B.M. I (1984). Embryology of Angiosperms, Springer-Verlag, Netherlands.

GE3	Plant Anatomy and Embryology (Practical: 2 credits)
Practical :	
<ol style="list-style-type: none"> 1. Study of anatomical details through permanent slides/temporary stain mounts/ Photographs 2. Study of anomalous secondary growth in <i>Tinospora</i>, <i>Bignonia</i>, <i>Boerhaavia</i>, and <i>Dracaena</i> through temporary preparations and permanent slides 3. Study of morphological and anatomical adaptations in hydrophytes and xerophytes through specimens and temporary slide preparations 4. Photographs of pollen grains 5. Study of anther, ovule, double fertilization, endosperm and embryo through photographs 	

SEMESTER – IV

GE4: Plant Physiology and Metabolism

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Understand Water relation of plants with respect to various physiological processes
CO2: Know about mineral nutrition
CO3: Know the details of Respiration and Photosynthesis
CO4: Comprehend the Biological nitrogen fixation and its importance

GE4	Plant Physiology and Metabolism (Theory: 4 credits)
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Unit	Topics to be covered	No. of Lectures
1	Plant-water relations: Transpiration and factors affecting transpiration, mechanism of stomatal movement and factors controlling it Mineral nutrition: Macro and micronutrients and their role in plant nutrition	12
2	Photosynthesis: 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	12
3	Respiration: Glycolysis, anaerobic respiration, TCA cycle; Oxidative phosphorylation, Glyoxylate, Oxidative Pentose Phosphate Pathway	12
4	Nitrogen metabolism: Biological nitrogen fixation; Hormone: A general account; Movements: Phototropic and Geotropic movements	12
	TOTAL	48

Suggested Readings :

- Hopkins, W.G. and Huner, A. (2008). Introduction to Plant Physiology, John Wiley and Sons. U. S.A. 4th edition.
- Taiz, L., Zeiger, E., MØller, I.M. and Murphy, A (2015). Plant Physiology and Development, Sinauer Associates Inc. USA. 6th edition.
- Bajracharya D. (1999). Experiments in Plant Physiology-A Laboratory Manual, Narosa Publishing House, New Delhi.
- Jain V. K. (2014). Fundamentals of Plant Physiology, S. Chand & Company Ltd. 16th Revised edition.
- Verma V. (2016). Plant Physiology, Athena Academic. 2nd edition.
- Harborne, J.B. (1973). Phytochemical Methods, John Wiley & Sons. New York.
- Pathak, V.N., Khatri, N.K., Pathak, M. (2012). Fundamental of Plant Physiology, Agribios. 5th edition.

GE4	Plant Physiology and Metabolism (Practical: 2 credits)
Practical	
<ol style="list-style-type: none"> Determination of the rate of transpiration by using Farmer's Potometer Determination of the amount of water absorbed and transpired by a plant, using T/A apparatus Chemical separation of photosynthetic pigments by Paper Chromatographic Technique To study the effect of light intensity on the rate of photosynthesis To study the effect of carbon dioxide concentration on the rate of photosynthesis 	
Demonstration experiments	
<ol style="list-style-type: none"> Bell jar experiment Demonstration of osmosis using potato Moll's half leaf experiment Demonstration of light-screen experiment 	

Discipline Specific Elective (DSE)

Discipline Specific Elective (DSE) Course: Elective courses may be offered by the main discipline/subject of study is referred to as Discipline Specific Elective. The University/Institute may also offer discipline related Elective courses of interdisciplinary nature (to be offered by main discipline/subject of study).

DSE: Plant Breeding

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Understand the patterns of inheritance in different organisms
- CO2:** Know the basics of linkage of genes, sex determination and quantitative inheritance
- CO3:** Obtain knowledge of methods of crop improvement
- CO4:** Decipher various methods of plant propagation and its importance in human welfare

DSE1 Plant Breeding (Theory: 4 credits)		
Unit	Topics to be covered	No. of Lectures
1	Plant Breeding: Introduction and objectives. Breeding systems: modes of reproduction in crop plants. Important achievements and undesirable consequences of plant breeding.	10
2	Methods of crop improvement: Introduction: Centers of origin and domestication of crop plants, plant genetic resources; Acclimatization; Selection methods: For self-pollinated, cross pollinated and vegetative propagated plants; Hybridization: For self, cross and vegetative propagated plants – Procedure, advantages and limitations	20
3	Inbreeding depression and heterosis: History, genetic basis of inbreeding depression and heterosis; Applications.	10
4	Crop improvement and breeding: Role of mutations; Polyploidy; Distant hybridization and role of biotechnology in crop improvement	14
TOTAL		48

Suggested Readings :

1. 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.
2. Pierce BA (2011) Genetics: A Conceptual Approach, 4th Ed., Macmillan Higher Education Learning.
3. Singh, B.D. (2005). Plant Breeding: Principles and Methods, Kalyani Publishers. 7th edition.
4. Chaudhari, H.K. (1984). Elementary Principles of Plant Breeding, Oxford - IBH. 2nd edition.
5. Acquaah, G. (2007). Principles of Plant Genetics & Breeding, Blackwell Publishing.

DSE1	Plant Breeding (Practical: 2 credits)
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	<p>Practical :</p> <ol style="list-style-type: none"> 1. Mendel's laws through seed ratios. Laboratory exercises in probability and chi-square analysis 2. Incomplete dominance and gene interaction through seed ratios (9:7, 9:6:1, 9:3:4, 12:3:1, 13:3 and 15:1) 3. Hybridization techniques - Emasculation, Bagging (For demonstration only)
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DSE2: Biostatistics

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Comprehend the fundamental concepts related to descriptive and inferential biostatistics
- CO2:** Develop skills in data tabulation, its treatment, analysis, interpretation and graphical representation of data
- CO3:** Analyze the implications of inferential statistics in biology
- CO4:** Develop the competence in hypothesis testing and interpretation

DSE2		Biostatistics (Theory: 4 credits)
Unit	Topics to be covered	No. of Lectures
1	Biostatistics: Definition, statistical methods-basic principles Variables - measurements, functions, limitations and uses of statistics Collection of data (primary and secondary), types and methods of data collection, merits and demerits; Classification of data, tabulation and presentation, sampling methods	16
2	Measures of central tendency - mean, median, mode, geometric mean - merits & Demerits; Measures of dispersion - range, standard deviation, mean deviation, quartile deviation –merits and demerits; Co- efficient of variations	14
3	Correlation - types and methods of correlation, regression, simple regression equation, fitting prediction, similarities and dissimilarities of correlation and regression	10
4	Statistical inference - hypothesis - simple hypothesis - student 't' test - chi square test	08
TOTAL		48

Suggested Readings :

1. Danniel, W.W. (1987). Biostatistics, New York, John Wiley Sons.
2. Selvin, S. (1991). Statistical Analysis of epidemiological data, New York University Press.
3. Campbell, R.C. (1998). Statistics for Biologists, Cambridge University Press.
4. Arora, P.N. Malhan, P.K. (2006). Biostatistics, Himalaya Publishing House. 9th edition.
5. Pagano, M. Gauvreau K. (2004). Principles of Biostatistics, Duxbury. 1st edition.
6. Bhuyan, K.C. (2017). Advanced Biostatistics, New Central Book Agency (P) Ltd. 1st edition.

DSE2

Biostatistics
(Practical: 2 credits)

Practical :

1. Calculation of mean, standard deviation and standard error
2. Calculation of correlation coefficient values and finding out the probability
3. Calculation of 'F' value and finding out the probability value for the F value

SEMESTER – VI

DSE3: Research Methodology

Course Outcomes

After the completion of the course, the student will be able to:

- CO1:** Understand the concept of research and different types of research in the context of biology
- CO2:** Develop laboratory experiment related skills
- CO3:** Develop competence on data collection and process of scientific documentation
- CO4:** Understand the ethical aspects of research

DSE3		
Research Methodology (Theory:4 credits)		
Unit	Topics to be covered	No. of Lectures
1	Basic concepts of research: Research-definition and types of research (Descriptive vs. analytical; applied vs. fundamental; quantitative vs. qualitative; conceptual vs. empirical); Research methods vs. methodology; Literature-review and its consolidation; Library research; field research; laboratory research; Key biology research areas	12
2	General laboratory practices: Common calculations in botany laboratories; Understanding the details on the label of reagent bottles; Molarity and normality of common acids and bases; Preparation of solutions; Dilutions; Percentage solutions; Molar, molal and normal solutions; Technique of handling micropipettes; Knowledge about common toxic chemicals and safety measures in their handling	12
3	Data collection and documentation of observations: Maintaining a laboratory record; Tabulation and generation of graphs; Imaging of tissue specimens and application of scale bars; The art of field photography	08
4	The art of scientific writing and its presentation: Numbers, units, abbreviations and nomenclature used in scientific writing; Writing references; Powerpoint presentation; Poster presentation; Scientific writing and ethics; Introduction to copyright-academic misconduct/plagiarism	16
TOTAL		48

Suggested Readings :

1. Narayana P. S., Varalakshmi D. and Pullaiah T. (2016). Research Methodology in Plant Sciences, Scientific Publisher.
2. Arumugam N. (2015). Research Methodology, Saras Publication.
3. Napoleon D. (2014). Research Methodology: A Theoretical Approach, Laxmi Publication.
4. Sadasivam, S., Manickam, A. (2011). Biochemical Methods, New Age International Publishers. 3rd edition.
5. Raman. A., Mimmagadda J. (2009). A hand book of Research Process, McMillan Publishers India Pvt. Ltd. 1st edition.
6. Bhaskar A. (2014). Biochemical Methods : A Practical Approach, Narosa Publishing House. 1st edition.

DSE3	
Research Methodology (Practical: 2 credits)	
Topics to be covered	No. of hours
Practical : <ol style="list-style-type: none"> 1. Experiments based on chemical calculations 2. The art of imaging of samples through microphotography and field photography 3. Poster presentation on defined topics 4. Technical writing on topics assigned 	

DSE4: Dissertation (6 Credits)

Industrial and Environmental Microbiology

(Credits: Theory-4, Practical-2)

THEORY

Lectures: 60

Unit 1: Scope of microbes in industry and environment

(6 lectures)

Unit 2: Bioreactors/Fermenters and fermentation processes

(12 lectures)

Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous

fermentations. 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.

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; Filtration, centrifugation, cell disruption, solvent extraction, precipitation and ultrafiltration, lyophilization, spray drying; 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.

Practical

Principles and functioning of instruments in microbiology laboratory. Hands on sterilization techniques and preparation of culture media.

Industrial and Environmental Microbiology

(Credits: Theory-4, Practical-2)

THEORY

Lectures: 60

Unit 1: Scope of microbes in industry and environment

(6 lectures)

Unit 2: Bioreactors/Fermenters and fermentation processes

(12 lectures)

Solid-state and liquid-state (stationary and submerged) fermentations; Batch and continuous

fermentations. 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.

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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.

Practical

1. Principles and functioning of instruments in microbiology laboratory
2. Hands on sterilization techniques and preparation of culture media.

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.
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Horticultural Practices and Post-Harvest

Technology(Credits: Theory-4, Practical-2)

THEORY

Lectures: 60

Unit 1: Introduction

(4 lectures)

Scope and importance, Branches of horticulture; Role in rural economy and employment generation; Importance in food and nutritional security; Urban horticulture and ecotourism.

Unit 2: Ornamental plants

(4 lectures)

Types, classification (annuals, perennials, climbers and trees); Identification and salient features of some ornamental plants [rose, marigold, gladiolus, carnations, orchids, poppies, gerberas, tuberose, sages, cacti and succulents (opuntia, agave and spurges)] Ornamental flowering trees (Indian laburnum, gulmohar, Jacaranda, Lagerstroemia, fishtail and areca palms, semul, coraltree).

Unit 3: Fruit and vegetable crops

(4 lectures)

Production, origin and distribution; Description of plants and their economic products; Management and marketing of vegetable and fruit crops; Identification of some fruits and vegetable varieties (citrus, banana, mango, chillies 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 losses 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 and chemical methods for pest control); Quarantine practices; Identification of common diseases and pests 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.

Unit 10: Field trip

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.

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