ST. JOSEPH'S COLLEGE (AUTONOMOUS)

BENGALURU-27

Re-accredited with **'A++' GRADE with 3.79/4 CGPA** by NAAC
Recognized by UGC as College of Excellence

DEPARTMENT OF BOTANY

SYLLABUS FOR UNDERGRADUATE PROGRAMME

(AS PER NEP 2021)

For Batch 2021 Onwards

Part A			
1	Title of the Academic Program	BSc Chemistry Botany and Zoology (CEB, MCB, CBBt, BZBc)	
2	Program Code	**SJC BSc CBZ etc (To be given by Examination Section)**	
3	Name of the College	St. Joseph's College (Autonomous)	
4	Objective of the College	1. Academic Excellance 2. Character Formation 3. Social Concern	
5	Vision of the College	"Striving for a just, secular, democratic and economically sound society, which cares for the poor, the oppressed and the marginalized"	
6	Mission of the College	M1	St. Joseph's College (Autonomous) seeks to form men and women who will be agents of change, committed to the creation of a society that is just, secular and democratic.
		M2	The education offered is oriented towards enabling students to strive for both academic and human excellence.
		M3	The college pursues academic excellence by providing a learning environment that constantly challenges the students and supports the ethical pursuit of intellectual curiosity and ceaseless enquiry.
		M4	Human excellence is promoted through courses and activities that help students achieve personal integrity and conscientise them to the injustice prevalent in society.
7	Name of the Degree	Bachelor of Science (B.Sc.,)	
8	Name of the Department offering the program	Botany	
9	Vision of the Department offering the program	"The Department intends to inculcate in the students an interest to explore the world of Botanical science and contribute to the rapidly expanding field. We wish to offer the society, a generation of humble yet aspiring young minds eagerly striving towards unraveling the mystery of Plants"	
10	Mission of the department offering the Program	• The Department of Botany aim at identifying one's potential to become a centre for augmenting and contributing continuously to the vibrant field of plant sciences. • We strive to create and provide an ambient learning atmosphere and prepare students for academia, industry and productive application of the knowledge in everyday life. • It emphasizes the impact of plants on food, agriculture, environment and other human activities.	
11	Duration of the Program	3 years (Six semesters)	
12	Total No. of Credits	38	
13	Program Educational Objectives (PEOs)	PEO1	
		PEO2	
		PEO3	
Programme Educational Objectives: PEOs are statements that describe Institution's Mission aligned with the programme (To be Prepared in consultation with other departments (Languages			

and Optional subjects) 2-5 PEOs can be written.

- **Guidelines for the PEOs**
  - PEOs should be consistent with the mission of the Institution
  - The number of PEOs should be manageable
  - PEOs should be achievable by the program
  - PEOs should be specific to the program and not too broad

14	Graduation Attributes		The Following graduate attributes reflect the particular quality and feature or characteristics of an individual, that are expected to be acquired by a graduate through studies at St. Joseph's College. • **Disciplinary knowledge** • **Communication Skills** • **Critical thinking** • **Problem solving** • **Analytical reasoning** • **Research-related skills** • **Cooperation/Team work** • **Reflective thinking** • **Information/digital literacy** • **Self-directed learning and Lifelong learner** • **Multicultural competence** • **Moral and ethical awareness/reasoning** • **Leadership readiness/qualities** • **International Outlook**
15	Program Outcomes (POs)	PO1	
		PO2	
		PO3	
		PO4	

Programme Outcomes: POs are statements that describe what the students graduating from any of the educational Programmes should be able to do (To be Prepared in consultation with other departments (Languages and Optional subjects. 4-10 POs can be written

- **Guidelines for the POs**
  - Program outcomes basically describe **knowledge, skills and behavior** of students as they progress through the program as well as by the time of graduation.
  - POs should not be too broad
  - They must be aligned with the **Graduation Attributes**

16	Program Specific Outcomes (PSOs)	PSO1	Acquired knowledge and understanding of the botanical sciences as applicable to diverse areas such as food, agriculture, medical, industrial, environment, genetics, and others.
		PSO2	Demonstrate key practical skills/competencies in working with plants for study and use in the laboratory as well as outside, including the use of good agricultural practices.
		PSO3	Competent enough to use knowledge and skills of plant science to analyze problems involving plant- microbe interactions, food and agriculture, drug research, etc. and articulate these with peers/ team members/ other stake holders, and undertake remedial measures/ studies etc
		PSO4	Developed a broader perspective of the discipline of Botany to enable him to identify challenging societal problems and plan his/her professional

			career to develop innovative solutions for such problems.
		PSO5	
		PSO6	

Programme Specific Outcomes: PSOs are statements that describe what the graduates of a specific educational Programme should be able to do.
These statements are to be written by individual departments offering optional programmes. In addition Language departments also to write general statements for BA, BSc and Commerce Programs. For the Microbiology optional for MCB/MCZ PSOs have been shown as examples.
4-10 PSOs can be written

- **Guidelines for the PSOs**
  - Program Specific outcomes basically describe **knowledge and skills of** students as they progress through the program as well as by the time of graduation.
  - POs should not be too broad
  - They must be aligned with the **Graduation Attributes**

Part B

B.Sc. CBZ Curriculum
(B.Sc. CEB, MCB, CBBt, BZBc)

Courses and course completion requirements	No. of credits
General English	
Second language: Introductory Kannada/Kannada/ Hindi/ Sanskrit/ Tamil/ Additional English/French/German.	
Botany	06
Chemistry	
Zoology	
Microbiology	
Biotechnology	
Biochemistry	
Environmental science	
Open elective courses (non-professional)	03
Foundation courses	
Term paper	
Soft skills (IGNITORS)	
Human resource development (HRD)/Theology	
Outreach activity	
Extra and Co-curricular activities	

SUMMARY OF CREDITS IN BOTANY

DEPARTMENT OF BOTANY (UG)
(2021 onwards)

Semester 1	**Code Number**	**Title**	**No. of Hours of Instructions**	**Number of Hours of teaching per week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	BO-122	Microbial Diversity and Technology	56	04	04	30	70	100
Practical	BO-1P1	Microbial Diversity and Technology	56	04	02	15	35	50
Theory (OE)	BOOE-1	Gardening and Landscaping Technology	45	03	03			
Theory (OE)	BOOE-2	Mushroom Culture Technology	45	03	03			
Total Number of credits:			**09**					
Semester 2	**Code Number**	**Title**	**No. of Hours of Instructions**	**Number of teaching hrs /week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	BO-222	Diversity and Conservation of Non-Flowering Plants	56	04	04	30	70	100
Practical	BO-2P1	Diversity and Conservation of Non-Flowering Plants	56	03	02	15	35	50
Theory (OE)	BOOE-1	Entrepreneurship in Plant Based Drugs	45	03	03			
Theory (OE)	BOOE-2	Waste Management	45	03	03			
Total Number of credits:			**09**					
Semester 3	**Code Number**	**Title**	**No. of Hours of Instructions**	**Number of teaching hrs /week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	BO-321	Plant Anatomy and Developmental Biology	56	04	04	30	70	100
Practical	BO-3P1	Plant Anatomy and Developmental Biology	56	03	02	15	35	50
Theory (OE)	BOOE-5	Algal and Fungal Biotechnology	45	03	03			
	BOOE-6	Narcotic plants	45	03	03			
Theory (OE)								

DEPARTMENT OF BOTANY (UG) (2021 onwards)								
Semester 4	**Code Number**	**Title**	**No. of Hours of Instructions**	**Number of Hours of teaching per week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	BO-421	Ecology and Conservation Biology	56	04	04	30	70	100
Practical	BO-4P1	Ecology and Conservation Biology	56	04	02	15	35	50
Theory (OE)	BOOE-7	Organic farming	45	03	03			
Theory (OE)	BOOE-8	Plant based cosmetics	45	03	03			
Total Number of credits:			**09**					
Semester 5	**Code Number**	**Title**	**No. of Hours of Instructions**	**Number of teaching hrs /week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	BO-5121	Plant Taxonomy and Resource Botany	45	03	03	30	70	100
Practical	BO-5P1	Plant Taxonomy and Resource Botany	45	03	03	15	35	50
Theory	BO-5221	Cell Biology and Genetics	45	03	03	30	70	100
Practical	BO-5P2	Cell Biology and Genetics	45	03	03	15	35	50
Total number of credits:								
Semester 6	**Code Number**	**Title**	**No. of Hours of Instructions**	**Number of teaching hrs /week**	**Number of credits**	**Continuous Internal Assessment (CIA) Marks**	**End Semester Marks**	**Total marks**
Theory	BO6121	Plant Physiology and Biochemistry	45	03	03	30	70	100
Practical	BO6P1	Plant Physiology and Biochemistry	45	03	03	15	35	50
Theory (OE)			45	03	03			
			45	03	03			
Theory	BO6221	Plant Biotechnology	45	03	03	30	70	100
Practical	BO6P2	Plant Biotechnology	45	03	03	15	35	50
Theory (OE)								

Course Outcomes and Course Content

Semester	**I**
Paper Code	**BO-122**
Paper Title	**Microbial Diversity and Technology**
Number of teaching hours per week	04
Total number of teaching hours of theory per semester	56

Number of theory credits	04
Total number of teaching hours of practicals per semester	56
Number of practicals credits	02

Objective of the Paper:

- To understand basic concepts of Microbiology.
- To know the different characteristics of viruses, viroids, bacteria, fungi and lichens and to appreciate the significance of each of them.
- To gain a basic understanding of techniques of microscopy, microbial culture and preservation and sterilization methods.
- To appreciate the diversity and uses of fungi and to apply learnt concepts in fungi and Plant Pathology for the exploration of useful and harmful Fungi.
- To study diverse plant pathogens, symptoms of plant diseases and their control measure will be applied in Agriculture and Food Security.

Content of Theory Course 1		**56 Hrs**
Unit I		**12**
Chapter No. 1	**Microbial diversity -** Introduction to microbial diversity; Hierarchical organization and positions of microbes in the living world. Whittaker's five-kingdom system. Distribution of microbes in soil, air, food and water.	**3**
Chapter No. 2	**History and developments of microbiology -** Microbiologists and their contributions (Leeuwenhoek, Louis Pasteur, Robert Koch, *Edward Jenner and Alexander Fleming*).	**2**
Chapter No. 3	**Microscopy -** Working principle and applications of light and electron microscopes (SEM and TEM). Microbiological staining –principles of staining, types of staining - Simple, Gram's, Acid Fast, Endospore and Capsule staining.	**7**
Unit II		**07**
Chapter No. 4	**Culture media for Microbes -** Natural and synthetic media, Routine media - basal media, enriched media, selective media, indicator media, transport media, and storage media.	**2**
Chapter No. 5	**Sterilization methods -** Principle of disinfection, antiseptic, tyndallisation and Pasteurization, Sterilization - Sterilization by dry heat, moist heat, UV light, ionizat radiation, filtration. Chemical methods of sterilization - phenolic compounds, anion cationic detergents.	**3**
Chapter No. 6	**Bacterial Growth** –Growth curve and measurement. Definition of nutritional types of Microbes - autotrophs and heterotrophs, phototrophs and chemotrophs; lithotrophs and organotrophs.	**2**
Unit III		**20**
Chapter No. 7	**Microbial cultures and preservation** - Pure culture, subculturing, Preservation methods-overlaying cultures with mineral oils, lyophilisation. Microbial culture collections and their importance. A brief account on ITCC, MTCC and ATCC.	**3**

Chapter No. 8	**Viruses** - General structure and classification of Viruses; ICTV system of classification. Structure and multiplication of TMV, CMV, and Bacteriophage (T2). Cultivation of viruses. Brief account of Viroids, prions and vaccines.	**6**
Chapter No. 9	**Bacteria** - General characteristics and classification. Archaebacteria and Eubacteria. Ultrastructure of Bacteria - Structure of capsule, flagella, pili and endospore. (Ultrastructure of flagella and endospore only), Physical and chemical structure of Gram positive and Gram negative bacterial cell walls. Reproduction by binary fission. Genetic recombination by conjugation (F+ and F-, Hfr types), Transduction (generalized and specialized types) and Transformation. Study of *Rhizobium* and its applications. A brief account of Actinomycetes. Phytoplasmas - General characteristics and diseases. Economic importance of Bacteria.	**11**
Unit IV		**21**
Chapter No. 10	**Fungi** - General characteristics and classification (Alexopoulos et al. 1996). Thallus organization and nutrition in fungi. Reproduction in fungi (asexual and sexual). Heterothallism and parasexuality. Type study of *Stemonitis, Pythium, Rhizopus, Puccinia, Penicillium* and *Trichoderma*. *Economic importance of fungi* ***(self study)***	**11**
Chapter No. 11	**Lichens** – Structure and reproduction. **VAM Fungi** and their significance. **Plant Pathology** - Study of Etiology, disease symptoms, vectors if any, disease cycle and control measures of following diseases: Tomato Leaf Curl, Citrus Canker, Sandal Spike, Club Root of Crucifer, Late Blight of Potato, Smut of Jowar Blast of Rice, Red Rot of Sugarcane	**10**

Text Books:

1. Ananthnarayan R and Panikar JCK. 1986. Text book of Microbiology. Orient Longman ltd. New Delhi.
2. Arora DR. 2004. Textbook of Microbiology, CBS, New Delhi.
3. William CG. 1989. Understanding microbes. A laboratory text book for Microbiology. W.H. Freeman and Company. New York.
4. Dubey RC and Maheshwari DK. 2007. A textbook of Microbiology, S. Chand and Company, New Delhi.
5. Dubey RC and Maheshwari DK. 2002. A Text book of Microbiology, S.C. Chand and Company, Ltd. Ramnagar, New Delhi.
6. Sharma R. 2006. Text book of Microbiology. Mittal Publications. New Delhi. 305pp.
7. Sharma PD. 1999. Microbiology and Plant Pathology. Rastogi publications. Meerut, India.
8. Vasanthkumari R. 2007. A textbook of Microbiology, BI Publications Pvt. Ltd., New Delhi.

References:
1. Alexepoulos CJ and Mims CW. 1989. Introductory Mycology, Wiley Eastern Ltd., New Delhi.
2. Allas RM. 1988. Microbiology: Fundamentals and Applications, Macmillan publishing co. New York.
3. Brook TD, Smith DW and Madigan MT. 1984. Biology of Microorganisms, 4th ed. Eaglewood Cliffts. N.J. Prentice-Hall. New Delhi.
4. Burnell JH and Trinci APJ. 1979. Fungal walls and hyphal growth, Cambridge University Press. Cambridge.
5. Jayaraman J. 1985. Laboratory Manual of Biochemistry, Wiley Eastern Limited. New Delhi.
6. Ketchum PA. 1988. Microbiology, concepts and applications. John Wiley and Sons. New York.
7. Michel J, Pelczar Jr.EC and Krieg CR. 2005. Microbiology, Mc.Graw-Hill, New Delhi.
8. Powar CB and Daginawala. 1991. General Microbiology, Vol – I and Vol – II Himalaya publishing house, Bombay.
9. Reddy S and Ram. 2007. Microbial Physiology. Scientific Publishers, Jodhpur, 385pp.
10. Sullia SB and Shantharam S. 1998. General Microbiology. Oxford and IBH publishing Co. Pvt. Ltd. New Delhi.
11. Schlegel HG. 1986. General Microbiology. Cambridge. University Press. London, 587pp.
12. Roger S, Ingrahan Y, Wheelis JL, Mark L and Page PR. 1990. Microbial World 5th edition. Prentice-Hall India, Pvt. Ltd. New Delhi.
13. Sullia SB. and Shantharam S. 2005. General Microbiology, Oxford and IBH, New Delhi.

BO 1P1: List of Experiments to be conducted

Practical 1: Safety measures in microbiology laboratory and study of equipment/appliances used for microbiological studies (Microscopes, Hot air oven, Autoclave/Pressure Cooker, Inoculation needles/loop, Petri plates, Incubator, Laminar flow hood, Colony counter, Haemocytometer, Micrometer etc.).
Practical 2: Enumeration of soil/food /seed microorganisms by serial dilution technique.
Practical 3: Preparation of culture media (NA/PDA) sterilization, inoculation, incubation of *E coli / B. subtilis/* Fungi and study of cultural characteristics.
Practical 4: Determination of cell count by using Haemocytometer and determination of microbial cell dimension by using Micrometer.
Practical 6: Simple staining of bacteria (Crystal violet /Nigrosine blue) / Gram's staining of bacteria.Isolation and study of morphology of *Rhizobium* from root nodules of legumes
Practical 7: Preparation of spawn and cultivation of paddy straw (Oyster) mushroom.
Practical 8: Study of vegetative structures and reproductive structures –*Stemonitis,Pythium, Rhizopus, Puccinia, Penicillium, Trichoderma (Depending on local availability)*
Practical 9: Preparation of agar slants, inoculation, incubation, pure culturing and preservation of microbes by oil overlaying.
Practical 10: Study of late blight of Potato, Downy mildew of Bajra, Citrus canker, Tobacco mosaic disease, Sandal spike disease.
Practical 11: Visit to water purification unit/Composting unit/ microbiology lab/ dairy and farms to understand role of microbes in day to day life

Course Outcomes and Course Content

Semester	**II**
Paper Code	**BO 222**
Paper Title	**Diversity of Non-Flowering Plants**
Number of teaching hours per week	04
Total number of teaching hours of theory per semester	56
Number of theory credits	04
Total number of teaching hours of practicals per semester	56
Number of practicals credits	02

Objective of the Paper: Plants, to most people, mean a wide range of living organisms from the smallest bacteria to the largest living things - the giant *Sequoia* trees. By this definition plants include: algae, fungi, lichens, mosses, ferns, conifers and flowering plants.

To understand the thallus organization, diversity, identification techniques and classification of Algae, Bryophytes, Pteridophytes, and Gymnosperms. To understand algal cultivation techniques and to appreciate the wide usage of non-flowering plants in human welfare.

To study and understand the morphological, internal structure and the reproductive structures of diverse plant groups for the evolution of structure-functions and their application. To understand the geological time scale and fossil taxa of various classes to appreciate the plants evolution, paleoclimate conditions.

BO 221: Diversity of Non-Flowering Plants

Content of Theory Course 2		**56 Hrs**
Unit I		**17**
Chapter No. 1	**Algae** –General characteristics and classification of algae (Fristch system, 1945), Diversity- habitat, thallus organization, pigments, reserve food, flagella types, life-cycle and alternation of generation in Algae.	**5**
Chapter No. 2	Morphology and life-cycles of *Anabaena,Oedogonium, Chara, Vaucheria, Sargassum* and *Batrachospermum*. Diatoms and their importance.	**7**
Chapter No. 3	**Algal cultivation** - Cultivation of microalgae - *Spirulina* and *Dunaliella;* Algal cultivation methods in India. **Algal products** - Food and Nutraceuticals, Feed stocks, food colorants; fertilizers, aquaculture feed; therapeutics and cosmetics; medicines; dietary fibres from algae and uses. **Harmful effects of algae:** Algal blooms and toxins.	**5**

Unit II		**16**
Chapter No. 4	**Bryophytes** – General characteristics and classification of Bryophytes (Proskauer 1957), Salient features of class: Hepaticopsida, Anthocerotopsida, and Bryopsida	**3**
Chapter No. 5	Morphology, anatomy and reproduction of *Marchantia, Anthoceros, Funaria* (developmental details not required). Economic importance of Bryophytes. Fossil Bryophytes.	**5**
Chapter No. 6	**Pteridophytes** - General characteristics and classification; Distribution, morphology, anatomy, reproduction and life-cycles in *Psilotum, Lycopodium, Selaginella, Equisetum, Marsilea.*	**8**
Unit III		**15**
Chapter No. 7	A brief account of heterospory and seed habit. Stelar evolution in Pteridophytes. Affinities and evolutionary significance of Pteridophytes. Ecological and economic importance.	**5**
Chapter No. 8	**Gymnosperms -** General characteristics. Distribution and classification (Christenhusz et al., 2011) of Gymnosperms. Study of the habitat, distribution, habit, anatomy, reproduction and life-cycles in *Cycas*, *Pinus* and *Gnetum*.	**8**
Chapter No. 9	Affinities and evolutionary significance of Gymnosperms. Economic importance of Gymnosperms - food, timber, industrial uses and medicines.	**2**
Unit IV		**13**
Chapter No. 10	**Origin and evolution of Plants:** Origin and evolution of plants through Geological Time scale.	**2**
Chapter No. 11	**Paleobotany -** Paleobotanical records, plant fossils, Preservation of plant fossils - impressions, compressions, petrifications, nodules, moulds and casts. Radiodating. Exploration of fossil fuels. Contributions of Birbal Sahni.	**6**
Chapter No. 12	Fossil taxa - *Rhynia, Lepidodendron, Calamites, Glossopteris* and *Pentoxylon*.	**5**

Text Books:

1. Chopra, G.L. A text book of Algae. Rastogi & Co., Meerut, Co., New Delhi, Depot.Allahabad.
2. Johri, Lata anf Tyagi, 2012, A Text Book of, Vedam e Books, New Delhi.
3. Sharma, O.P. 1990. Text Book of Pteridophyta. McMillan India Ltd. New Delhi.
4. Sharma, O.P. 1992. Text Book of Thallophytes. McGraw Hill Publishing Co. New Delhi.
5. Sharma, O.P., 2017, Algae Singh-Pande-Jain 2004-05. A Text Book of Botany. Rastogi Publication, Meerut.

References:

1. Sambamurty, A.V.S.S.. A Text Book of Algae. I.K. International Private Ltd., New Delhi.
2. Agashe, S.N. 1995. Paleobotany. Plants of the past, their evolution, paleoenvironment and Allied plants. Hutchinson & Co., Ltd., London.

3. Anderson R.A. 2005, Algal cultural Techniques, Elsievier, London.
4. Publication, Application in exploration of fossil fuels. Oxford & IBH., New Delhi.
5. Eams, A.J., (1974) Morphology of vascular plants - Lower groups. Tata McGraw-Hill Publishing Co. New Delhi, Freeman & Co., New York.
6. Fritze, R.E. 1977. Structure and reproduction of Algae. Cambridge University Press.
7. Goffinet B and Shaw A.J. 2009, Bryophyte Biology, 2nd ed. Cambridge University Press, Cambridge.
8. Srivastava, H N, 2003. Algae. Pradeep Publication, Jalandhar, India.
9. Kakkar, R.K. and B.R.Kakkar (1995) The Gymnosperms (Fossils and Living) Central Publishing House, Allahabad.
10. Kumar H. D., 1999, Introductory Phycology, Affiliated East-West Press, Delhi.
11. Lee, R.E., 2008, Phycology, Cambridge Unversity Press, Cambridge. 4th edition. McGraw Hill Publishing Co., New Delhi.
12. Parihar, N.S. 1970. An Introduction to Embryophyta. Vol. I. Bryophyta. Central Book, Allahabad.
13. Parihar, N.S. (1976) An Introduction to Pteridophytes, Central Book Depot, Allahabad.
14. Parihar, N.S. 1977. The Morphology of Pteridophytes. Central Book Depot, Allahabad Press, Cambridge.
15. Rashid, A. 1998. An Introduction to Pteridophyta. II ed., Vikas Publishing House, New Delhi.
16. Smith, G.M. 1971. Cryptogamic Botany. Vol. II. Bryophytes & Pteridophytes. Tata McGraw Hill Publishing, New Delhi.
17. Smith, G.M. 1971. Cryptogamic Botny. Vol.I Algae & Fungi. Tata McGraw Hill Publishing. New Delhi.
18. Sporne, K.R. 1965. The Morphology of Gymnosperms. Hutchinson & Co., Ltd., London.
19. Stewart, W.M. 1983. Paleobotany and the Evolution of Plants, Cambridge University Cambridge.
20. Sundarajan, S. 1997. College Botany Vol. I. S Chand & Co. Ltd., New Delhi.
21. Vanderpoorten, A. and Goffinet, B. 2009, Introduction to Bryophytes, Cambridge University Press, Cambridge.
22. Vashista, B.R. 1978. Bryophytes. S Chand & Co. Ltd., New Delhi.

BO 2P1: List of Experiments to be conducted

Practical-1: Study of morphology, classification, reproduction and lifecycle of *Anabaena, Scytonema, Spirulina.*
Practical-2: Study of morphology, classification, reproduction and life-cycle of *Oedogonium, Chara,Vaucheria,Sargassum, Batrachospermum.*
Practical-3: Study of morphology, classification, reproduction and life-cycle of*Marchantia&Funaria*.
Practical-4: Study of morphology, classification, anatomy, reproduction and life-cycle of *Psilotum, Lycopodium, Selaginella.*
Practical -5: Study of morphology, classification, anatomy, reproduction and life-cycle of *Equisetum, Marsilea.*
Practical -6: Study of morphology, classification, anatomy and reproduction in *Cycas*.
Practical -7: Study of morphology, classification & anatomy, reproduction in *Pinus*.
Practical -8: Study of morphology, classification & anatomy, reproduction in *Gnetum*.
Practical -9: Study of algal diversity from freshwater bodies.
Practical 10: Study of fossils – *Rhynia, Lepidodendron, Calamites, Glossopteris* and Pentoxylon.
Practical-11: Visit to algal cultivation units/lakes with algal blooms/Fern house/Nurseries/Geology museum/lab to study plant fossils.

(**Note:** Botanical study tour to a floristic rich area for 1-2 days and submission of study report is compulsory)

Course Outcomes and Course Content

Semester	**III**
Paper Code	**BO-321**
Paper Title	**Plant Anatomy and Developmental Biology**
Number of teaching hours per week	04
Total number of teaching hours of theory per semester	60
Number of theory credits	04
Total number of teaching hours of practicals per semester	60
Number of practicals credits	02

Objective of the Paper:

- Observation of variation that exists in the internal structure of various parts of a plant as well as among different plant groups in support for the evolutionary concept.
- Skill development for the proper description of internal structure using botanical terms, their identification and further classification.
- Understanding the basic concepts in plant morphogenesis, embryology and organ development.

Content of Theory Course 1		**60 Hrs**
Unit I – Plant Anatomy		**16**
Chapter No. 1	**Plant cell**: Ultrastructure, function and organization of plant cell wall (primary and secondary).	**3**
Chapter No. 2	Meristematic tissue and its types, Permanent tissues - Simple and complex tissues, Structural organization of shoot apical meristem - Theories of organization (Apical, Histogen, Tunica-Corpus); root apical meristem (Korper-Kappe theory), quiescent center concept and *cytohistological zonation (Self study)*.	**6 + 1**
Chapter No. 3	Secretory tissues-types, structure and importance	**2**
Chapter No. 4	Types of Vascular bundles - collateral, bicollateral, concentric, medullary bundle, Internal phloem, *Types of Nodal anatomy-Unilacunar, Trilacunar and multilacunar (Self study)*.	**3 + 1**
Unit II		**14**
Chapter No. 5	**Leaf anatomy** : Internal structure of dorsiventral and isobilateral leaves; Structure of stomata.	**3**

Chapter No. 6	**Stem anatomy:** Primary xylem, Concept of protoxylem and metaxylem; *Wood anatomy; Variation in wood structure: heartwood, sapwood, ring porous and diffuse porous*; Wood parenchyma; Uniseriate and Multiseriate rays; Apotracheal and Paratracheal parenchyma.	**3+ 2**
Chapter No. 7	Primary structure of root and stem (Dicot and Monocot); Secondary growth of dicot stem (*Helianthus*) and dicot root (Cicer).	**4**
Chapter No. 8	Anomalous secondary growth in the stem of *Boerhaavia* and *Dracaena*.	**2**
Unit III – Developmental Biology of flowering plants		**30**
Chapter No. 9	**Plant Morphogenesis**: Introduction, history and scope of Plant Morphogenesis. **Organogenesis in Plants**: Cellular and Genetic basis of leaf development. *Types of phyllotaxy (self study).* Transformation of vegetative apex to floral apex, Development of floral organs in *Arabidopsis*. *Role of MADS box genes in flower development (self study)*	**4 + 2**
Chapter No. 10	Structure of Microsporangium - Anther wall, sporogenous tissue. **Microsporogenesis** : Microspore tetrads and its types, Development of Male gametophyte.	**5**
Chapter No. 11	**Palynology**: Pollen morphology: Apertures, exine stratification and Ornamentation. NPC classification. Applications of palynology.	**5**
Chapter No. 12	Structure of megasporangium, Ovule and its types (based on (a) position of chalaza, micropyle and funicle, (b) amount of nucellus, (c) number of integuments); megasporogenesis – monosporic, bisporic and tetrasporic type. Placentation and their types.	**6**
Chapter No. 13	*Pollination, Self and cross-pollination, their advantages and limitations (Self study).*	**2**
Chapter No. 14	Double fertilization- Definition, process, importance and uniqueness in angiosperms. Structure of dicot and monocot embryos (*Capsella bursa-pastoris, Oryza sativa).* Differences between mature Dicot and Monocot embryos.	**4**
Chapter No. 15	**Endosperm**: Development and Function. Types of Endosperm: i) Nuclear ii) Cellular iii) Helobial	**2**

Note: 8 hours of self study can be given

Text Books:

1. Botany for Degree Students, A.C.Dutta, Oxford University Press
2. Anatomy of Angiosperms, V. Singh, A.C. Pande and D.K.Jain, Rastogi Publication
3. Anatomy and Embryology of Angiosperms, Singh, Pande and Jain, Rastogi Publication
4. Plant Anatomy, M.S.Tayal, Rastogi Publication
5. Plant Anatomy, B. P. Pandey, S. Chand and Comp. Ltd. .
6. Anatomy of Seed Plants, K. Esau, John Wiley and Sons publication.
7. Plant Anatomy, Pijush Roy, New Central Book Agency (P) Ltd.

8. Plant Anatomy, P.J. Chandurkar, Oxford and IBH Publishing Co. Pvt. Ltd.
9. An Embryology of Angiosperms, S.S.Bhojwani and S.P Bhatnagar, Vikas Publishing House
10. An Introduction to Embryology of Angiosperms, P. Maheshwari, McGraw Hill Publication.
11. Raghavan V.R.2000. Developmental biology of flowering plants. Springer publications.
12. Sinnot E.W. 1960.Plant morphogenesis. Mc Graw Hill Book Company, INC, New York.
13. Wardlaw 1968. Morphogenesis in plants, Methuen and Co

BO 3P1: List of Experiments to be conducted

Practical 1: T.S of dicot and monocot leaves.
Practical 2: T.S of dicot and monocot stem and roots.
Practical 3: Anomalous secondary growth in *Boerhaavia* and *Dracaena*
Practical 4. Study of phyllotaxy in different plants.
Practical 5: L.S. of flower; T.S of young and mature anther
Practical 6: Semi-permanent slide preparation of pollen grains and study of its morphology – Grass, *Cocos nucifera, Hibiscus, Mimosa, Acacia, Tridax, Eucalyptus* and Pollinia of *Calotropis*
Practical 7. Germination of Pollen grains of *Catharanthus roseus* – Hanging Drop method
Practical 8. Types of placentation & ovules
Practical 9. Mounting of endosperm of *Cucumis*
Practical 10. Mounting of embryo of *Tridax*

Course Outcomes and Course Content

Semester	**IV**
Paper Code	**BO-421**
Paper Title	**Ecology and Conservation Biology**
Number of teaching hours per week	04
Total number of teaching hours of theory per semester	60
Number of theory credits	04
Total number of teaching hours of practicals per semester	60
Number of practicals credits	02

Objective of the Paper:

- The objective of this course is to help students master the concepts and key skills that are needed to obtain and be successful in a job working as a conservation biologist in a government agency, non-profit organization, or academia.

Learning outcomes:

- Student will learn key ecological concepts, which will be extensively used to tackle conservation issues.
- Students will learn key skills such as using tools and techniques in vegetation assessment, water quality analysis, wildlife census technique and natural resource management.

Content of Theory Course 1		**60 Hrs**
Unit I		**20**
	Ecology: Introduction, sub-divisions **Ecological factors -** **Abiotic factors:** Climatic factors - Light and Temperature; Soil profile. (*Edaphic factors affecting vegetation (soil water, soil microbes, and pH* - **self-study**) **Biotic factors:** Ecological interactions- a) Commensalism (Epiphytes-*Orchid* and Lianas-*Entada*) b) Protocooperation (Gut bacteria *E. coli* and *Enterococcus faecalis*) c) Mutualism (*Rhizobium,* Lichens and Mycorrhiza) d) Parasitism (*Cuscuta, Rafflesia, Viscum and Santalum*) e) Allelopathy (*Eucalyptus*) **Ecosystem:** Definition, components, food chain, food web and ecological pyramids.	**17+3 hour self-study**

	Productivity and Energy flow, Biogeochemical cycles: Gaseous cycles - (Nitrogen and *Carbon cycle* - **self-study**) and Sedimentary cycles (Phosphorous and *Sulphur cycle* - **self-study**) **Ecological successions:** Process and examples: hydrosere and xerosere.	
Unit II		**10**
	Population Ecology - Characteristics of population Restoration Ecology with case study – Bandipur Tiger Reserve Invasive Species Ecology with case study (*Lantana camara*) Ecological Niche – Definition, Types, Ecological Niche Modeling (ENM) and species recovery *(Ecosystem services-types and payments* - **self-study)**	**9+1 hour self-study**
Unit III		**20**
	Biological diversity and plant communities: Structure of communities Methods of studying vegetation: Plot methods (Quadrat and transect methods). **The world's biomes:** Freshwater, Marine, Desert, Forest, Grassland & Tundra. Conservation and preservation of biomes. **Biodiversity and conservation:** Biodiversity - Definition, threats to biodiversity, keystone species Convention on Biodiversity (CBD) IUCN Red List categories and criteria Invasive Alien Species (IAS) – Issues and Prospects Conservation strategies (*in-situ:* Medicinal Plant Conservation Areas (MPCAs), Protected Areas (PAs), and *ex-situ*: Botanical Garden, Zoos, Aquariums, seed bank, Captive breeding of animals and artificial propagation of plants) *(Biodiversity hotspots in India* - **self study)** *(Red data book* - **self-study)** An overview on conservation laws in India: (The Biological Diversity Act, 2002; The Environment (Protection) Act, 1986; The Forest (Conservation) Act, 1980; The Wildlife Protection Act, 1972; The Indian Forest Act, 1927)	**17+3 hours self-study**
Unit IV		**10**
	Global Environmental Issues: *(Climate change and its impacts-Greenhouse effect and global warming; Acid rain, Ozone layer depletion - **self-study**)* Carbon sequestration, carbon foot prints **Natural Resource Management**, Non-timber Forest Products (NTFPs), Traditional Ecological Knowledge (TEK), Eco Development Committee (EDC), Joint Forest Management (JFM), Sacred Groves and Community based conservation	**9+1 hour self-study**

Note: 8 hours of self-study can be given

Text Books:

- Foin, T.C. (1996) Ecological System and Environment, Mifflin, Boston.
- Fred Van Dyke, (2008) Conservation Biology: Foundations, Concepts, Applications, 2nd Edition, Springer, Dordrecht.
- Heywood, V.H. and Watson R.T. (1995) Global Biodiversity Assessment, Cambridge University Press.
- Kormondy, E.J. (1996) Concepts of Ecology, Prentice Hall India, New Delhi.
- Martha J. Groom, Gary K. Meffe, C. Ronald Carroll, (2014) Principles of Conservation Biology, Oxford University Press, UK.
- Mueller-Dombois, D. and Ellenberg, H. (1974) Aims and Methods of Vegetation Ecology, John Wiley and Sons, New York.
- Nobel, B.J. and Wright R.T. (1995) Environmental Science, Prentice Hall, New Jersey.
- Odum, E.P. (1971) Fundamentals of Ecology, W.B. Saunders Co., Philadelphia.
- Pandey, B.W. (2005) Natural Resource Management, Mittal Publication, New Delhi.
- Sharma, P.D. (2003) Ecology and Environment. 7th Edition, Rastogi Publication, Meerut.
- Wittenberg, R. and Cock, M.J.W. (eds.) 2001. Invasive Alien Species: A Toolkit of Best Prevention and Management Practices. CAB International, Wallingford, Oxon, UK, xvii - 228.

BO 4P1: List of Experiments to be conducted

Practical 1: Vegetation assessment tools and techniques - GPS, Quadrat, Clinometer, Compass, Vernier Calipers, DBH & measuring tapes, Densiometer, Ropes etc.
Practical 2: Enumeration of campus trees and IVI Calculation
Practical 3: Calculation of Shannon Diversity Index
Practical 4: Ecological instruments
Practical 5: Water quality analysis – Chlorides
Practical 6: Water quality analysis – Dissolved Oxygen
Practical 7: Ecological Adaptations – Set 1 (Xerophytes, Hydrophytes)
Practical 8: Ecological Adaptations – Set 2 (Halophytes, Epiphytes, Parasitic plants)
Practical 9: Study of common Invasive Alien Species in India – *Lantana, Parthenium, Eupatorium, Alternanthera, Prosopis* etc.
Practical 10: Questionnaire survey to address conservation issues

Course Outcomes and Course Content

Semester	**V**
Paper Code	**BO-5121**
Paper Title	**Plant taxonomy and Resource Botany**
Number of teaching hours per week	04
Total number of teaching hours of theory per semester	45
Number of theory credits	03
Total number of teaching hours of practicals per semester	45
Number of practicals credits	02

Content of Theory Course 1		
Unit I		
Chapter No. 1	**Introduction & Principles of taxonomy:** Description - The plant body - Root, stem and leaves: types and their modifications. Inflorescence types, flower- parts and their arrangements, fruit types; Identification, Nomenclature, Classification (phylogeny of Angiosperms, its significance)	**5**
Chapter No. 2	Herbarium technique, herbaria, Botanical gardens and their importance. Contributions of Carl Linnaeus and Indian Taxonomists (E.K. Janaki Ammal & Fr. Cecil J Saldanha) (self study). Botanical Survey of India (Self study). Outline of classification - Bentham and Hooker's system, Engler and Prantl's system ("Syllabus der Pflanzenfamilien", ed. Melchior,1964), An introduction to APG System of classification.	**3+2**
Chapter No. 3	Principles and rules (ICN); ranks and names; binominal system, typification	**2**
Unit II		
Chapter No. 4	Modern systematics – Need for a synthetic approach, role of Palynology, phytochemistry and serology, DNA barcoding.	**3**
Chapter No. 5	Vegetative and floral characters of flowering plants used in taxonomy in the description families. Salient features of the families given below – (According to Engler & Prantl "Syllabus der Pflanzenfamilien", ed. Melchior, 1964). **Dicotyledonous families:** Magnoliaceae, Moraceae, Brassicaceae, Malvaceae, Fabaceae, Caesalpiniaceae, Mimosaceae, Rutaceae, Euphorbiaceae, Apiaceae, Apocynaceae, Asclepiadaceae, Solanaceae, Lamiaceae, Acanthaceae, Rubiaceae, Cucurbitaceae and Asteraceae. **Monocotyledonous families:** Poaceae, Liliaceae, Cannaceae, Musaceae and	**26**

	Orchidaceae. Brief economic uses of the members of the above-mentioned families	

Note: 4 hours of self study can be given

References:

•Ashok Bendre and Ashok Kumar (1980) Economic Botany. Rastogi and Publications, Meerut.
• Heywood V.H. (1967) Plant Taxonomy. Edward Arnold, London.
• Hill A.F. (1982) Economic Botany. McGraw Hill, New York.
•Jeffrey C. (1968) An introduction to plant taxonomy, London.
•Lawrence, F.H.M. (1969) Taxonomy of vascular plants. Oxford & IBH Publications, New Delhi.
•Singh and Jain, D.K. (1989) Taxonomy of angiosperms. Rastogi and Publications, Meerut.
•Sundararajan,S. (2000) College Botany Vol. III. Himalayan Publishing House, Mumbai.
•Sivarajan, V.V. (1982) Introduction to principles of plant taxonomy. Oxford & IBH Publications, New Delhi.
•B.S.Sharma and B.B. Trivedi (1978) Introductory taxonomy. L B Publications.
•Gurcharan Singh (2019) Plant Systematics: An Integrated Approach, IV Edition.CRC Press, •Simpson, M.G. (2019) Plant Systematics, 3rd Edition. Academic Press, USA.
•Harris, J.G. and Harris, M.W. (2001) Plant identification terminology: An illustrated glossary Second Edition. Spring Lake Publishing, Spring Lake, Utah.
•Beentje, H. (2010)The Kew Plant Glossary: an illustrated dictionary of plant terms. Royal Botanic Gardens, Kew,UK.
•Bell, A. D. (1991) Plant Form: An Illustrated Guide to Flowering Plant Morphology. Oxford University Press, Oxford

BO 5P1: List of Experiments to be conducted

Detailed studies of the following families with locally available plant specimens (depending on the availability of specimens)

1. Magnoliaceae, Moraceae, Brassicaceae
2. Fabaceae, Caesalpiniaceae, Mimosaceae
3. Malvaceae, Rutaceae, Euphorbiaceae,
4. Apiaceae, Apocynaceae, Asclepiadaceae
5. Solanaceae, Lamiaceae, Acanthaceae
6. Rubiaceae, Cucurbitaceae, Asteraceae
7. Poaceae, Liliaceae, Orchidaceae
8. Musaceae and Cannaceae
9. Economic Botany: Common name, botanical name, family to which they belong, morphology of the part being used and uses of
    a) Cereals and Millets: Rice, Wheat, Jowar, Ragi
    b) Pulses: Black gram, Bengal gram, Green gram
    c) Spices: Cardamom, Clove, Cinnamon.
    d) Fibres: Cotton, Coir and Jute
10. Economic Botany: Common name, botanical name, family to which they belong, morphology of the part being used and uses of
    a) Paper and Pulp: Eucalyptus and Bamboo
    b) Sugar: Cane Sugar
    c) Beverages: Coffee and Tea
    d) Medicinal plants: Neem, Sarpagandha and Periwinkle.

• Submission of five economically important plant products.
• Preparation and submission of three herbarium specimens and three digital herbarium specimens (Soft copy).
• Local field trip for studying plants and plant specimen collection

Course Outcomes and Course Content

Semester	**V**
Paper Code	**BO-5221**
Paper Title	**Cell biology and Genetics**
Number of teaching hours per week	04
Total number of teaching hours of theory per semester	45
Number of theory credits	03
Total number of teaching hours of practicals per semester	45
Number of practicals credits	02

Objective of the Paper:

- To understand the structure and function of various cellular components
- To understand the process of cell division and its significance
- To understand basic concepts in Mendelian Genetics and gene interactions
- To be able to understand and solve the genetic problems

BO5221: Cell Biology and Genetics

Unit I	**Brief account of Cell organelles:** Plasma membrane, Endoplasmic reticulum, *Lysosomes*, Golgi bodies, Mitochondria, Plastids. Ultrastructure and functions of Nucleus **Cell Cycle:** G1, S, G2 and M phases, Check points. Mitosis: Stages, Mitotic apparatus and cytokinesis. Meiosis: Stages, Synaptonemal complex, crossing over and chiasma formation, *Significance of mitosis and meiosis (Self-study).*	**7+2 hrs**
Unit II	**Ultrastructure of Chromosome -** Nucleosome model, types of chromosomes based on position and number of centromeres. Concept of heterochromatin and euchromatin; Karyotype definition and procedure. Idiogram. Techniques to study chromosomes – Types of staining, chromosome painting. *Special chromosomes – B Chromosomes in plants and its significance (Self-study)*	**4+2 hrs**
Unit III	**Chromosomal aberrations:** Introduction and types Numerical: Euploidy (Monoploidy, Haploidy and Polyploidy) Polyploidy- Autopolyploidy and Allopolyploidy. Aneuploidy- Monosomy, Nullisomy and Trisomy. Structural - Deletions (Terminal, Interstitial), Duplication (Tandem, Reverse tandem and Displaced), Translocation (Reciprocal, non reciprocal) and Inversions (Pericentric and Paracentric). Significance of chromosomal aberrations. **Brief account of gene mutations** *–Mutagens-* *Physical mutagens – Physical (ionizing and non- ionizing radiations) (Self-study)*	**6+2 hrs**

	and chemical mutagens (Base analogs, Alkylating agents, Acridine dyes, Deaminating agents, Hydroxylating agents, Tobacco carcinogens); **Types of mutation:** Base substitution (Transition and transversion), Frame shift mutation, insertion, deletion, missense, nonsense, reverse, suppressor and lethal mutations.	
Unit IV	**Introduction to genetics:** *Mendel's experimental work (Self-study)*, Mendel's laws of inheritance. **Basic terms in genetics:** Gene, Allele, locus, dominant, Recessive, Homozygous, Heterozygous, Monohybrid cross, Dihybrid cross, Genotype, Phenotype, Punnett square, test cross, back cross, Reciprocal cross, Phenocopy, Pleiotropy, penetrance and expressivity,	**4+1 hrs**
Unit V	**Gene interactions:** **Intragenic interactions:** Incomplete dominance, Codominance, lethal genes **Intergenic interactions:** Complementary gene interaction, Supplementary gene interaction, Dominant Epistasis, Recessive Epistasis, Duplicate gene interaction, Polymeric gene interaction, Polygenic inheritance, Genetic problems based on gene interactions. **Extrachromosomal inheritance**: a) Cytoplasmic male sterility (Maize) b) Chloroplast inheritance (Mirabilis)	**7 hrs**
Unit VI	**Linkage:** Definition, Types of linkage-complete linkage and incomplete linkage, Linkage group, *Factors affecting linkage (Self-study),* Significance of linkage. **Crossing over:** concept, types (single, double (reciprocal chiasma, complimentary chiasma), multiple cross over, significance and process of crossing over.	**4+1hrs**
Unit VII	Genetic mapping in maize (Three-point test cross), Problems based on gene order, Recombination frequency, distance between the genes, interference and coefficient of coincidence Sex determination in plants *(Melandrium) Sex linked inheritance*	**5 hrs**

NOTE: 4 hours of self-study can be given.

BLUE PRINT

Code number: **BO 5221**

Title of the paper: **Cell Biology and Genetics**

Total marks for which the questions are to be asked (including bonus questions)	Number of hrs	Chapter/ Unit number
20	9	I
13	6	II
16	8	III
11	5	IV

14	7	V
11	5	VI
11	5	VII
96	**45**	**TOTAL**
Maximum marks for the paper (Excluding bonus question): **70**		

PRACTICALS
BO5P2: Cell Biology and Genetics

1. Preparation of acetoorcein and acetocarmine
2. Study of permanent slides in Mitosis (all stages)
3. Preparation and study of mitosis using root tips of *Allium cepa.*
4. Study of permanent slides in Meiosis
5. Preparation and study of meiosis using flower buds of *Allium cepa.*
6. Karyotyping
7. Practice problems on Mendelian genetics, gene interactions
8. Practice problems on Gene mapping, Recombination frequency
9. Practice problems on Linkage and crossing over
10. Submission to the batch teacher: Preparation of permanent slides in Mitosis (2) and Meiosis (2) (total 4 slides).

REFERENCES

- Biology: The Dynamic Science, 2nd Edition,Peter J. Russell, Paul E. Hertz.. Beverly Mc Millan publications. 2012
- Cell and Molecular Biology, 4th Edition, P.K. Gupta. 2014
- Cell Biology, 10th Edition, S.P. Singh and B. S. Tomar. 2014.
- Cytogenetics, 1st Edition, P.K. Gupta. 2013
- Genes- IX, 9th Ed., Benjamin Lewin. Jones and Bartlett Publishers, 2008.
- Genetics – Classical to modern, 1st Edition. P.K. Gupta. 2013.
- Principles of Genetics, 7th Edition, Robert H. Tamarin. 2002. Tata- Mc Graw Hill publications.
- Theory and Problems of Genetics. W. D. Stansfield. 2002. Mc Graw Hill publications.
- Gardner, E. J., Simmons, M. J., D. P. (2008). Principles of genetics VIII Edition. Wiley India
- Snustad, D. P., Simmons M. J. (2009) Principles of genetics V Edition. John Wiley and Sons
- Karp, Cell and Molecular Biology: Concepts and Experiments, 6th ed. USA: Wiley and Sons, 2009.
- D. L. Nelson and M. M. Cox. Lehninger's Principles of Biochemistry, 6th ed. USA: W. H. Freeman. 2013.
- P. S. Verma and V.K. Agarwal, Cell Biology, Genetics, Molecular Biology, Evolution and Ecology, New Delhi: S. Chand and Co. Pvt. Ltd., 2010.

Course Outcomes and Course Content

Semester	**VI**
Paper Code	**BO-6121**
Paper Title	**Plant Physiology and Biochemistry**
Number of teaching hours per week	03
Total number of teaching hours of theory per semester	44
Number of theory credits	03
Total number of teaching hours of practical per semester	44
Number of practical credits	02

Objective of the Paper:

- To understand the basic functions and intermediary metabolism in a plant body.
- To gain awareness on the interdisciplinary nature of Botany and Chemistry by studying the principles of plant life, growth and reproduction.
- To recognizing the interrelationship that exist between metabolic pathways, thereby gaining an idea about the importance of plants in the dynamicity of nature.

Content of Theory Course 1		**44Hrs**
Unit I		**08**
Chapter No. 1	**Water relations of plants :** Diffusion, osmosis, imbibition, plasmolysis, water potential and its components.	**2**
Chapter No. 2	**Absorption of water and ascent of sap:** The mechanism of water absorption, factors affecting the rate of water absorption. Ascent of sap: **Pulsation theory of J.C. Bose** and Transpiration pull and cohesion-tension theory of Dixon and Jolly.	**2 + 1**
Chapter No. 3	**Transpiration:** Stomatal opening and closing mechanism: K+ ion theory, factors influencing transpiration, **antitranspirants and guttation.**	**2 + 1**
Unit II		**08**
Chapter No. 4	**Mineral elements in plants.** The essential elements and their functions, symptoms of deficiency, ion antagonism; hydroponics, aeroponics and foliar nutrition. Absorption of mineral salts: Ion uptake mechanism, factors affecting mineral uptake, ion channels.	**3 + 1**
Chapter No. 5	**Phloem transport**: Transport of organic solutes (use of radioactive isotopes, tracer, and autoradiography), loading and unloading; transport mechanism (protoplasmic streaming hypothesis,	**4**

	Mass flow hypothesis). Factors affecting phloem transport.	
Unit III		**18**
Chapter No. 6	**Photosynthesis:** Bioenergetics, structure of chloroplast and Ultrastructure of thylakoid membrane, principles of light absorption, photosystems I and II. Photosynthetic electron transfer and photophosphorylation, mechanism of ATP synthesis (Chemiosmotic hypothesis), mechanisms of carbon fixation and carbohydrate synthesis, C3 cycle, C4 pathway, CAM pathway**. <u>Factors affecting the rate of photosynthesis and Blackmann's law of limiting factors.</u>** Photorespiration: Mechanism, organelles involved and significance	**9 +1**
Chapter No. 7	**Respiration :** Ultrastructure of cristae, Respiratory Quotient, Glycolysis, TCA cycle, ETS and Oxidative phosphorylation, anaerobic respiration (Alcoholic fermentation), Pentose phosphate pathway – significance. Factors affecting the rate of respiration.	**8**
Unit IV		**10**
Chapter No. 8	**Plant growth and photobiology :** **<u>Definition of growth and sigmoid growth curve</u>**. Growth regulators – Auxins, Gibberellins, Cytokinins, Abscisic acid and Ethylene. **<u>Role of plant hormones in growth and development</u>.** Plant movements. Dormancy, seed viability and germination. Phytochrome and its role in growth and development, Photoperiodism, vernalization, Florigen concept, ABC and ABCDE Models.	**8 + 2**

Note: 4 hours of self study can be given

Text Books:

- Srivastava, H. N, (2007).Plant Physiology, Rastogi Publications
- Mukherji, S. and Gupta A. K,(2005). Plant physiology. New Central Book Agency, New delhi.
- Salisbury F.B. and Ross C.W. 1986. Plant Physiology.CBS Pub. New Delhi.

References:

- Dey, P.M., &Horborne, J.N., 1977. Plant Biochemistry, Academic Press, New York
- Goodwin &Mercep., 1993. Introduction to plant biochemistry, Pergamon Press, New York
- Hall, D.O., & Rao, K.K., 1999. Photosynthesis 6th ed., Published in association with the Institute of Biology, Cambridge University Press.
- Moore, T.C., 1989. Biochemistry and Physiology of Plant hormones, Narosa Pub. House, New Delhi.
- Singh, B.N., &Mengel, K., 1995. Plant physiology and biochemistry, Panima Pub. Corporation, New Delhi.
- Singal, G.S., Genger, G.C., Sopory, S.K., Irrgang, K.D., &Govindjee, 1999. Concepts in photobiology, photosynthesis and photomorphogenesis, Narosa Pub. House, New Delhi.
- Stumpf, P.K., & Conn, E., (eds) 1988. The biochemistry of plants - A comprehensive treatise, Academic Press, New York

- **<u>BO 6P1:</u> Plant Physiology and Biochemistry**

Total: 44 Hours

(11 Sessions 4hrs/Week)

1. Observation of plasmolysis and determination of osmotic potential by plasmolytic method.
2. Study of stomatal types and determination of Stomatal Index in monocot and dicot leaves.
3. Setting up of Solution culture/ hydroponics for demonstration of deficiency syndrome.
4. Study of the effect of temperature on membrane permeability using conductivity meter.
5. Separation of photosynthetic pigments by paper chromatography and finding their Rf values.
6. Estimation of total chlorophyll by spectrophotometer method.
7. Estimation of fructose in different fruits by resorcinol method.
8. Estimation of Leghaemoglobin from root nodules of leguminous plants.
9. Instruments as spotters (Clinostat, Arc auxanometer, Ganong's potometer, suction force by thistle funnel, Ganong's respirometer).
10. Seed germination study under different environmental conditions.
11. Revision

Course Outcomes and Course Content

Semester	**VI**
Paper Code	**BO-6221**
Paper Title	**Plant Biotechnology**
Number of teaching hours per week	03
Total number of teaching hours of theory per semester	45
Number of theory credits	03
Total number of teaching hours of practicals per semester	45
Number of practicals credits	02

Objective of the Paper:

- To understand the origin, development and basic concepts of Biotechnology.
- To understand the fundamental aspects of plant tissue culture and plant secondary metabolites production using biotechnology and their application.
- To understand molecular biology of plants and production of transgenic plants and their application.
- To understand the concepts of modern technology pertaining to large scale production of plant products.
- To apply the concepts of molecular biology and plant biotechnology to the field of plant sciences.

Content of Theory Course		**45 Hrs**
Unit I		**12**
Chapter No. 1	***Introduction to Biotechnology:*** *Definitions, History, Development, Scope and Importance of biotechnology (Self-study).*	**2**
Chapter No. 2	**Plant Biotechnology: Plant Tissue Culture -** Definition, history, principle, scope and Importance of plant tissue culture. ***in vitro*** **culture techniques:** Totipotency, Sterilization methods, Culture media – composition, types of medium and role of hormones in tissue culture. Inoculation, Incubation and Acclimatization.	**4**
Chapter No. 3	**Plant tissue culture – Applications in plant improvement and conservation-** Callus, single cell and suspension culture and its significance. Organ culture -Anther, Embryo and Meristem culture. Organogenesis, somatic embryogenesis and artificial seeds.	**6**
Unit II		**20**
Chapter No. 4	**Recombinant DNA Technology:** *Introduction to rDNA technology (Self-study).* **Tools and techniques** - host organism – bacteria, virus, plasmid, phage DNA,	**9+1**

	DNA manipulative enzymes – restriction enzymes, ligase, T4 Polynucleotide kinase, alkaline phosphatase, Reverse transcriptase, and Taq polymerase. Terminal deoxyribonucleotidyl transferase. Construction of recombinant DNA. **Cloning vectors**– plasmids, cosmids and BAC **Expression vectors** – Design and construction	
Chapter No. 5	**Molecular Biology techniques and their applications:** Agarose gel electrophoresis, Southern, Northern and Western blotting, Polymerase Chain Reaction.	**5**
Chapter No. 6	**Gene isolation and characterization:** Isolation of genes of interest - construction of genomic DNA library and cDNA library **DNA sequencing:** Maxam-Gilbert and Sanger methods of gene sequencing	**5**
Unit III		**7**
Chapter No. 7	**Gene delivery system:** Direct (Particle gun bombardment, microinjection, electroporation) and Indirect (*Agrobacterium* mediated) gene transfer. **Plant Molecular Biology –**Genetic organization of Ti plasmids, Functions encoded by integrated T-DNA.	**4**
Chapter No. 8	**Application of Recombinant DNA Technology in Agriculture -** Engineering plants for resistance to pest and disease, tolerance to herbicides and abiotic factors. **Environmental applications** – *bioremediation (Self study)*	**2+1**
Unit IV		**6**
Chapter No. 9	**Transgenic plants** – Production and current status. Improvement of medicinal and aromatic plants using biotechnology for human welfare.	**2**
Chapter No. 10	Principle and Importance of Biosafety, Biohazards and Bioethics, Intellectual Property Rights issues in plant biotechnology. Patenting – Definition, Importance and Applications.	**4**

Note: 4 hours of self study can be given

Text Books:

1. Gupta, P. K. 1994. Elements of Biotechnology. Rastogi Publications. Meerut.
2. Maheshwari, P. and Rangaswamy, N.S. (Eds.) 1963. Plant, Tissue and organ culture.
3. Old, R.W., and Primrose, S.B. (5th Ed.) 1994. Principles of gene manipulations Blackwell Science
4. Razdan, M.K. 1993. An introduction to plant tissue culture. Oxford and IBH Publishing Co. Pvt. Ltd. New Delhi.
5. Reinert, J.R., and Bajaj, Y.P.S. 1977. Applied and fundamental aspects of plant cell, tissue and organ culture. Springer-Verlag, Berlin
6. Sen, S.K. and Giles, K.L. (Ed.) 1983. Plant cell culture in crop improvement. Plenum Press, New York.
7. Street, H.E. 1977. Plant tissue and cell culture, Academic Press, Berkeley, University of California.
8. Kalyan Kumar De., 1997. Plant Tissue Culture – New Central Book Agency (P) Ltd., Calcutta.
9. Mascarenhas A.F., 1991. Hand book of Plant Tissue Culture. Indian Council of Agricultural Research. New Delhi.
10. Bajaj, Y.P.S. (Ed.) Biotechnology in agriculture and forestry. Various volumes published time to time. Springer-Verlag. Berlin
11. Bhojwani, S.S. 1990. Plant tissue culture: Applications and limitations. Elsevier Publishers, Amsterdam
12. Bhojwani, S.S., and Razdan, M.K. 1996. Plant tissue culture: Theory and Practice Elsevier Publishers, Amsterdam.

13. Dixon, R.A. and Gonzales, R.A. (Ed.) 1994. Plant cell culture, a practical approach. 2nd Edition. Oxford University Press, Oxford
15. Malik Zainul Abdin, Usha Kiran, Kamaluddin and Athar Ali (Eds). Plant Biotechnology: Principles and Applications. Springer.
16. Pareek, K.L. and Swarnkar, P.L. (2006). Trends in Plant Tissue Culture and Biotechnology. Agro bios, Jodhpur.
17. Ignacimuthu, S.1997. Plant Biotechnology. Oxford Publishing Co. Pvt. Ltd., New Delhi.

REFERENCE BOOKS:

1. Grierson, D and Convey, S.N., 1988. Plant Molecular Biology Published in the USA by Chapman and Hall, New York.
2. Dubey, R.C.1993. Text Book of Biotechnology. S. Chand & Company Ltd., New Delhi.
3. Brown, T.A. 1994. Gene cloning, Chapman and Hall Pub.
4. Trivedi P.C. 2001. Algal Biotechnology.
5. Rashid, A. 2009. Molecular physiology and Biotechnology of Flowering plants. Narosa Publishing House Pvt. Ltd., New Delhi.
6. Slater, A., Scott, W.N. and Flower, R.M. 2008. Plant Biotechnology – the Genetic Manipulation of Plants. 2nd edition. Oxford University Press Inc., New York.
7. Draper, J. 1988. Plant Genetic Transformation and Gene Expression. Blackwell Scientific Publications, Oxford.
8. Old, R.W., and Primrose, S.B. 2004. Principles of Gene Manipulation. An introduction to Genetic Engineering. 5th Edition, Blackwell Science Publications.
9. Sambrock, J., Fritch, E.F., and Maniatis, T. 1989. Molecular cloning- a laboratory manual.
10. Potrykus, I., and Spangenberg, G. 1995. Gene transfer to plants. Springer, Berlin, Heidelberg.
11. Watson, J.D., and Baker, T.A., Bell, S.P. Gann, A. and Levine, M. 2004. Molecular Biology of Genes. 5th Edition, Pearson Education.

BO 6P2: List of Experiments to be conducted

1. Biotechnology lab design organization, sterilization techniques, nutrient medium.
2. Basic techniques of plant tissue culture – Media composition and preparation, sterilization protocols.
3. Morphogenetic studies *in vitro* on any one plant system (Seed culture, multiplication of shoots, rooting and hardening).
4. Isolation of explants, establishment, subculture and maintenance of callus.
5. Anther culture for haploid production.
6. Preparation of synthetic seeds.
7. Hairy root culture.
8. DNA isolation and separation by electrophoresis.
9. DNA amplification by PCR.
10. RAPD analysis for genetic diversity analysis in plants.