ST JOSEPH 'S UNIVERSITY, BENGALURU - 560027

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

DEPARTMENT OF BOTANY

SYLLABUS FOR POSTGRADUATE PROGRAMME

2024 ONWARDS

Part A			
1	Title of the Academic Program	M.Sc., Botany	
2	Program Code	**(To be given by Examination Section)**	
3	Name of the University	St. Joseph's University	
4	Objective of the University	1. Academic Excellence 2. Character Formation 3. Social Concern	
5	Vision of the University	"Striving for a just, secular, democratic and economically sound society, whichcares for the poor, the oppressed and the marginalized"	
6	Mission of the University	M1	St. Joseph's University seeks to form men and women who will be agents of change, committed to the creation of a society that is just, secular anddemocratic.
		M2	The education offered is oriented towards enabling students to strive forboth academic and human excellence.
		M3	The college pursues academic excellence by providing a learning environment that constantly challenges the students and supports the ethicalpursuit 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 injusticeprevalent in society.
7	Name of the Degree	Master of Science (M.Sc.) in Botany	
8	Name of the Department offering the program	Botany	
9	Vision of the Department offering program	"The Department intends to inculcate in the students an interest to explore the world of Plants 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 Plant Science"	
10	Mission of the Department offering 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 Botany. • 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 environment and the human activities.	
11	Duration of the Program	2 years (Four semesters)	
12	Total No. of Credits	94	

13	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**

Part B

M.Sc. Botany Curriculum

Courses and course completion requirements	No. of credits
Botany	100
Outreach activity/IGNITORS	04

SUMMARY OF CREDITS

DEPARTMENT OF BOTANY (PG) (2024 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 7123	Microbiology, Mycology & PlantPathology	60	04	04	50	50	100
Theory	BO 7223	Algae & Bryophytes	60	04	04	50	50	100
Theory	BO 7323	Pteridophytes and Gymnosperms	60	04	04	50	50	100
Theory	BO 7423	Taxonomy of Angiosperms and Economic Botany	60	04	04	50	50	100
Theory	BO 7523	Plant Breeding & PlantPropagation	60	04	04	50	50	100
Practical	BO 7P1	Microbiology, Mycology & Plant Pathology	88	04	02	15	35	50
Practical	BO 7P2	Algae & Bryophytes	88	04	02	15	35	50
Practical	BO 7P3	Pteridophytes and Gymnosperms	88	04	02	15	35	50
Practical	BO 7P4	Biostatistics & Bioinformatics	88	04	02	15	35	50
Practical	BO 7P5	Plant Breeding &Plant Propagation	88	04	02	15	35	50
Total Number of credits:			**30**					
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 8123	Pteridophytes & Gymnosperms	60	04	04	50	50	100
Theory	BO 8223	Biostatistics and	60	04	04	50	50	100

		Bioinformatics						
Theory	BO 8323	Plant Morphogenesisand Embryology	60	04	04	50	50	100
Theory	BO 8423	Tools and Techniquesin Plant Sciences	60	04	04	50	50	100
Theory	BO 8523	Plant Physiology and Metabolism	60	04	04	50	50	100
Practical	BO 8P1	Pteridophytes & Gymnosperms	88	04	02	15	35	50
Practical	BO 8P2	Biostatistics and Bioinformatics	88	04	02	15	35	50
Practical	BO 8P3	Plant Morphogenesis and Embryology	88	04	02	15	35	50
Practical	BO 8P4	Tools and Techniques in Plant Sciences	88	04	02	15	35	50
Practical	BO 8P5	Plant Physiology and Metabolism	88	04	02	15	35	50
Total Number of credits:			**30**					

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 9124	Ecology & Environmental Biology	60	04	04	50	50	100
Theory	BO 9224	Cell Biology, Genetics and Molecular Biology	60	04	04	50	50	100
Theory	BO 9324	Biotechnology	60	04	04	50	50	100
Theory(DE)	BODE 9424	Advanced Physiology (Elective)	60	05	04	50	50	100
Theory(DE)	BODE 9524	Plant Tissue Culture (Elective)	60	05	04	50	50	100

Note: Students can choose one of the departmental electives from BODE 9424 or BODE 9524								
Theory (DE)	BODE 9624	Microbiology (Elective)	60	05	04	50	50	100
Theo ry (DE)	BODE 9724	Systematics of Angiosperms (Elective)	60	05	04	50	50	100
Note: Students can choose one of the departmental electives from BODE 9624 or BODE 9724								
Practical	BO 9124	Ecology & Environmental Biology	88	04	02	15	35	50
Practical	BO 9224	Cell Biology, Geneticsand Molecular Biology	88	04	02	15	35	50
Practical	BO 9324	Biotechnology	88	04	02	15	35	50
Practical	BODE 9424	Advanced Physiology (Elective)	88	04	02	15	35	50
Practical	BODE 9524	Plant Tissue Culture (Elective)	88	04	02	15	35	50
Practical	BODE 9624	Microbiology (Elective)	88	04	02	15	35	50
Practical	BODE 9724	Systematics of Angiosperms (Elective)	88	04	02	15	35	50
Total Number of credits:			**30**					

Semester 4	**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**
		Research Project			10			
		IGNITORS/ OUTREACH			04			
Total Number of credits:			**14**					
Total No. of Credits : 104								
KEY WORDS: DE – Departmental Elective								

SKILL ENHANCEMENT COURSE (SEC) – **Any practical oriented and software based courses offered bydepartments to be listed below**	
Course Title	Code Number
Plant Tissue Culture	BO 9P5
Biostatistics & Bioinformatics	BO 8P2
Systematics of Angiosperms	BO 9P7

Course Objectives and Learning Outcomes

Semester	III
Paper Code	**BO 9124**
Paper Title	**Ecology and Environmental Biology**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Course Objectives

- To help students to master the concepts (basic to advance) of Ecology and Environment Biology.
- To teach/learn key skills, tools and techniques Ecology and Environment Biology that are required to address wider range of environmental problems from local to global.
- To pursue career as an Ecologist/Environmentalist/Conservation Biologist in government/non-government organizations/academia.

Unit I	**Ecology and Ecosystem:** Types, structure and function, food chain, food web and ecological pyramids. Productivity and energy flow - (10% rule, box and pipe model). **Nutrient flow** – Biogeochemical cycles – Gaseous cycles (Carbon and Nitrogen cycle) and Sedimentary cycles (Phosphorous and Sulphur cycle) *Ecological successions; types, process and examples- hydrosere and xerosere (Self-study).* **Population Ecology:** **Characteristics of Population** – Size, density, abundance, natality, mortality, age structure, biotic potential, carrying capacity, population fluctuations and regulation, population dispersal. **Population Structure** – dispersion, aggregation, isolation and territoriality. Ecological niche and Ecological Niche Modelling (ENM). *Interactions among populations – Commensalism, Amensalism, Protocooperation, Symbiosis, Myrmecophily, Predation and Parasitism, Competition – intraspecific and interspecific (Self-study)*	**4 hrs** + *1 hr* **7 hrs** + *2 hrs*
Unit II	**Plant Communities:** Structure of communities, methods of studying vegetation – Plot methods, (Quadrat method, transect methods) and Plotless methods (Point method) **Forest types:** Introduction to Indian Forest types by Champion and Seth, Tropical Evergreen Forests, Deciduous Forests (dry and moist), Grasslands, Boreal forests, Tundra biome, Deserts and Mangroves. **Biodiversity and Conservation:** Biodiversity and its levels, threats to biodiversity, IUCN Red List categories and criteria. Convention on Biodiversity (CBD). *Biodiversity hotspots in India, Red data book (Self-study).*	**14 hrs** +*1 hr*
	Diversity Indices: Measuring diversity using statistical tools and techniques – R, PAST	**3 hrs**
Unit III	**Environmental Pollution:** **Air pollution** – Sources of air pollution, primary air pollutants (oxides of Carbon, Nitrogen and Sulphur) and secondary air pollutants (tropospheric ozone and photochemical smog). Effects and control measures (local and global scale), Ambient air quality	

	standards. **Water pollution** – Sources of water pollution, major categories of water pollutants, ground water and surface water pollution, effects (Physiochemical, biological, pathogenic and toxic effects) and control measures. **Soil pollution -** causes and consequences **Heavy metal pollution** – Concept of biomagnifications, Mercury and Lead pollution. **Global Environmental Issues:** *Global warming and climate change, acid rain, ocean acidification, ozone layer depletion, Ecological footprint and Carbon footprint (Self-study).*	**7 hrs** *+ 2 hrs*
	Alternative energy resources - Mitigation of environmental issues using alternative energy resources – solar, wind, tidal.	**3 hrs**
	Waste Management: Management of municipal solid waste (MSW), waste water treatment, bioremediation and phytoremediation in brief. *e-waste and management (Self-study).*	**5 hrs** *+ 1hr*
	Sustainable Development: Sustainable agriculture, sustainable forestry and sustainable urbanization. Environmental Impact Assessment (EIA) and Biodiversity Impact Assessment (BIA).	**4 hrs**
Unit IV	**Remote Sensing**: Principles of remote sensing. The electromagnetic spectrum. **Data acquisition platforms:** Aircrafts, LANDSAT, SPOT, ERS, IRS, INSAT. **Sensors:** Visible, infrared and microwave (RBV, MSS, TM, ETM, MICROWAVE, WiFS, AVHARR, LISS and PAN Systems). Resolution. Data acquisition and interpretation. **Data products:** Photographs and False color satellite imageries, CCT. Principles of visual interpretation, Digital analysis and ground truth. Stereo viewing, CCD's. **Applications of remote sensing:** Forest estimation and vegetation studies. Applications in agriculture, water resources, geology and geomorphology, environment, coastal and ocean management, land use mapping and planning. GIS. *Indian Remote Sensing Programme and future perspectives in remote sensing (Self-study).*	**5 hrs** *+ 1hr*

NOTE: Portions which are underlined and italics are meant for self-study

References

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2. Foin, T. C. (1996). Ecological system and environment, Mifflin, Boston.
3. Gabor Farkas. (2017). Practical GIS: Learn novice to advanced topics such as QGIS, Spatial data analysis, and more. Packt Publishing.

4. Heywood, V.H. and Watson R.T. (1995). Global Biodiversity Assessment, Cambridge University pass.
5. Hill, M. K. (1997). Understanding environmental pollution, Cambridge University Pass.
6. Kormondy, E. J. (1996). Concepts of Ecology, Prentice Hall India, New Delhi.
7. Lillesand T. M. and Kiefer R.W. (1987). Remote Sensing and Image Interpretation, John Wiley and Sons, New York.
8. Mason, C. F. (1991). Biology of fresh water pollution, Longman publication.
9. Mullar-Dombois, D. and Ellenberg, H. (1974). Aims and Methods of Vegetation Ecology - Willey, New York.
10. Nobel, B. J. and wright R.T. (1996). Environmental Science, Prentice Hall, New Jersey.
11. Odum, E. P. (1971). Fundamentals of Ecology, Saunders, Philadelphia.
12. R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.
13. Richards, J. A. and Jia, X. (2006). Remote Sensing Digital Image Analysis – An Introduction. 4th Edition. Springer.
14. Sharma, P.D. (2003). Ecology and Environment. 7th Edition, Rastogi Publication, Meerut.
15. Sutherland, W. J. (2006). Ecological Census Techniques a Handbook: Second Edition, Cambridge University Press.
16. Treshow, M. (1985). Air pollution and plant life. Wiley Inter science.

BO 9P1: Ecology and Environmental Biology

Total: 44 Hours (11 Sessions and 4hrs/Week)

1. Study of vegetation by Quadrat method and determination of importance value index (IVI).
2. Estimation of Carbon storage in a given tree species.
3. **Analysis of water samples:** Estimation of Dissolved Oxygen and Chlorides.
4. **Analysis of water samples:** Estimation of Carbonates and Bicarbonates.
5. **Ecological Adaptations:** Xerophytes, Hydrophytes, Halophytes, Epiphytes and Parasites.
6. **Ecological Instruments:** Maximum and Minimum thermometer, Thermohygrograph, Aneroid barometer, Altimeter, Rain gauge etc.
7. **Ecological Instruments:** Measuring weather/climatic factors using Anemometer, CO_2 meter, Lux/Photo meter, Digital sound level meter in different Environment.
8. Analyzing environmental data using R and PAST Software.
9. Mapping Protected Area using QGIS.
10. **Questionnaire survey:** Understanding social dimensions of conservation issues.
11. Revision, question paper pattern description and certification of the record.

Learning Outcomes (LOs)

After completion of the course – Student will be able

LO1	To be familiar with theoretical as well as practical knowledge in Ecology and Environmental Biology.
LO2	To define/explain core concepts in Ecology - Population Ecology and Community Ecology.
LO3	To understand and learn methods, tools and techniques (quadrat and transect method) and interpretation skills that required to assess vegetation and infer the results for future directions.

LO4	To understand environmental problems (local to global), their root causes and consequences.
LO5	To understand wide range of ecological adaptations, ecological interactions among species with reference to their habitat and its significance in ecosystem.
LO6	To analyse and compare levels of biodiversity and its conservation as per the IUCN Species categories, Red Data Book and Biodiversity hotspots.
LO7	To analyse important water quality parameters with respect to water pollution and its control.
LO8	To use/operate wide range of ecological instruments and allometric equations in environmental research as per their principle, methods, and applications.
LO9	To be equipped with key concepts, methodologies and applications of GIS and Remote Sensing for biodiversity conservation.
LO10	To equipped with two statistical software; R and PAST for ecological data analysis.
LO11	To learn process and steps involved of Environmental Impact Assessment (EIA) and Biodiversity Impact Assessment (BIA).
LO12	To learn questionnaire survey method to understand social dimensions of conservation issues.
LO13	To develop suitable conservation strategies based on the theoretical and practical knowledge gained through the course (key concepts, methodologies and applications).
LO14	To articulate his/her environmental ethics, and actions to reduce his/her ecological footprint.

Course Outcomes and Course Content

Semester	**III**
Paper Code	**BO9224**
Paper Title	**Cell Biology, Genetics and Molecular Biology**
Number of teaching hours per week	**04**
Total number of teaching hours per semester	**60**
Number of credits	**04**

Objectives of the Paper

- To define components of the cell, terminologies used in genetics, DNA, RNA and protein, mutation and its types, population genetics.
- To draw ultrastructure of all cell organelles, DNA and RNA
- To interpret various genetic interactions and their role in determining the phenotype and genotype of an organism
- To calculate genetic distance and explain the importance of genetic distance with respect to crossing over and linkage
- To describe the structure and functions of cell organelles, DNA and RNA
- To explain the process of DNA replication, transcription and translation in both prokaryotes and eukaryotes
- To investigate the role of various proteins and enzymes involved in replication, transcription, post transcriptional modifications and translation
- To develop and understanding of how mutation affects the gene and controls the phenotype of the organism
- To compare and contrast underlying principles of genetic interactions and interpret the findings
- To illustrate the concept of operon and its regulation

Unit I: *Ultra structure of cell membrane, nucleus and nucleolus (self study)* Ultra structure of mitochondria, plastids, endoplasmic reticulum, Golgi bodies, lysosome, and peroxysomes. Cytoskeleton and its role. Cell cycle and the mechanism of cell cycle regulations. Cell cycle checkpoints, role of cyclins and cyclin dependent kinases	**8+2**
Unit II: Ultra structure of eukaryotic chromosome, Centromere - kinetochore complex, centromere proteins (CENPs), Sister chromatid cohesion; C-value paradox, DNA renaturation kinetics, cot curve	**7**

Unit III: *Mendelism (self study)* Non-Mendelian inheritance - incomplete and co-dominance, multiple alleles (maize, blood group), lethal genes. Gene interactions- supplementary, complementary, epistasis, inhibitory genes, duplicate genes (plant examples only). Inheritance of quantitative characters - polymerism, multiple genes. Linkage & Crossing over; Gene mapping	**9+2**
Unit IV: Mutation-importance, types, causes; DNA repair Mechanism (mismatch, base excision)	**2**
Unit V: Population genetics – Gene pool, Gene frequency, Genetic drift, Hardy-Weinberg law	**2**
Unit VI: Genetic material and its molecular structure: *Experimental evidence of DNA as genetic material (self study).* DNA structure, Alternative conformations of DNA, DNA replication models in eukaryotes (conservative, semi-conservative and dispersive). DNA replication in prokaryotes and Eukaryotes, Replication in telomere (Telomerase)	**5+2**
Unit VII: Gene Expression **Transcription:** Bacterial RNA polymerase- structure and function Eukaryotic RNA polymerases- types, and function, Mechanism of transcription-initiation, elongation and termination in prokaryotes and eukaryotes. Post transcriptional modifications: RNA editing (capping, polyadenylation, splicing, cryptic splicing, alternative splicing, exon shuffling); RNA types, (hnRNA, mRNA, tRNA, rRNA, snRNA, small RNA) and functions; Ribozyme **Translation:** t-RNA identity, amino acylation of t-RNA, amino acyl t-RNA synthetase, Mechanism of translation in both prokaryotes and eukaryotes, *Genetic code (discovery and its characteristic features) (self study).* Wobble hypothesis **Gene regulation in prokaryotes:** Cis regulatory factors, promoters, enhancers, operators, silencers; trans regulatory factors, transcription factors, Lac operon, tryptophan operon **Gene regulation in eukaryotes:** Transcription activators, transcriptional repression, gene silencing by modification of histone and DNA (Acetylation, Deacetylation and methylation), Mechanism of miRNA and siRNA mediated gene silencing.	**13+2**
Unit VIII: Protein Targeting: Posttranslational targeting: transport of proteins to Nucleus, Mitochondria, chloroplast, peroxisomes Co-translational targeting: Transport of proteins to ER, Golgi, Lysosomes, Plasma membrane, cytoplasm	**6**

NOTE: 8 hours of self-study assigned

REFERENCES

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- Gardner EJ, Simmons MJ and Snustad DP (1991). Principles of Genetics - 8th edition, John Wiley, New York.
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Code number: **BO 9224**

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

Total marks for which the questions are to be asked (including bonus questions)	Number of hrs	Chapter/Unit number
12	10	I
10	7	II
14	11	III
2	2	IV
2	2	V
10	7	VI
20	17	VII
6	4	VIII
76	**60**	**TOTAL**
Maximum marks for the paper (Excluding bonus question):**50**		

BO 9P2: Cell Biology, Genetics and Molecular Biology

Total: 44 Hours

1. Preparation of stains and reagents for cytology.
2. Study of mitosis in onion root tips and prepare a permanent mount of the same
3. Study of meiosis in onion flowers and prepare a permanent mount of the same
4. Induction of mitotic chromosomal aberrations using Colchicine, Ethylmethane sulphonate (EMS) in onion root tip cells
5. Study of catenation ring in *Rhoeo discolor*
6. Genetic problems (monogenic, digenic, testcross, Genetic interactions)
7. Genetic problems (Population genetics, Linkage and Gene mapping)
8. Isolation of genomic DNA from plants using Cetyl trimethyl ammonium bromide (CTAB) method.
9. Separation of genomic DNA by Agarose gel electrophoresis.
10. Estimation of RNA concentration by orcinol method
11. Revision

Course Outcomes: At the end of the Course, the Students

)1	Have developed good knowledge of the cell biology and underlying genetic principles.
)2	Have developed a very good understanding about the structure and function of DNA, RNA and protein
)3	Are able to perform experiments to understand the cell division and its regulation
)4	Are able to apply the concepts of cell biology and molecular biology to understand the basic processes in life.
)5	Are able to design their own experiments to study molecular mechanism of gene action

COURSE OUTCOMES AND COURSE CONTENT

Semester	IV
Paper Code	**BO 9324**
Paper Title	**Biotechnology**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper: Student will be able to

LO1	Define and describe methods of recombinant DNA technology and the molecular mechanisms of the various DNA modification enzymes, restriction enzymes.
LO2	Construct restriction maps for both linear and circular DNA
LO3	Explain the properties of cloning and expression vectors
LO4	Compare and contrast different types of vectors
LO5	Visualise and decribe the construction and screening of genomic and c-DNA libraries.
LO6	Explain the molecular mechanism of tumor formation in *Agrobacterium* mediated infection in plants
LO7	Interpret *Agrobacterium* mediated genetic engineering of plants
LO8	Describe and differentiate between different vector less methods used for genetic transformation in plants
LO9	Define and describe PCR and its types.
LO10	Distinguish between the PCR types and their applications
LO11	Describe and extrapolate applications of CRISPR-cas9 - RNA-guided nuclease for genome editing
LO12	Define and explain nanobiotechnology and its applications
LO13	Illustrate and distinguish between the different DNA sequencing techniques – Sanger sequencing, pyrosequencing, NGS, Nanopore Technology (4G)
LO14	llustrate and summarize DNA barcoding technique
LO15	Explain citing exaamples – metabolite production through hairy root culture, disease resistance in plants by rDT, gene silencing in crop plants, terminator seed technology and production of edible vaccine.
LO16	Outline the isolation and purification of enzymes – Cellulase, Invertase, Pectinase
LO17	Explain with example, immobilization of enzymes
LO18	Describe fermenters and bioreactors with their working mechanisms
LO19	Explain and illustrate production of acetone-butanol by fermentation, production of antibiotics: Penicillin and Streptomycin, production of bioinsecticides: *Bacillus thuringiensis* and NPV

LO20	Describe and demonstrate production of SCP: *Spirulina and chlorella*
LO21	Describe and distinguish biofertilizers and biocontrol agents, citing examples of *Azospirillum, Rhizobium, Trichoderma*
LO22	Enumerate the concept of IPR
LO23	Describe and distinguish between patent, copyright, Trade mark and trade with relevant examples

Course Outcomes: At the end of the Course, the Students

CO1	Have developed a good knowledge of the history, development and scope of biotechnology and the contributions made by prominent scientists.
CO2	Are able to perform basic experiments of biotechnology in particular the development of hybrid organisms and their applications for the welfare of mankind.
CO3	Have developed a very good understanding of the tools and techniques of recombinant biotechnology for developing useful products for the welfare of environment and mankind.
CO4	Are able to apply the learnt concepts of biotechnology to develop novel products and their better utilization as per the present day need.

COURSE CONTENT

Unit I	**Recombinant DNA technology:** Introduction, steps involved in recombinant DNA technology. **Tools in rDNA technology** - DNA modification enzymes - RE's (their role in restriction mapping) - Vectors used for cloning – Introduction, Plasmid (pBR322 and pUC series), Bacteriophage (Lambda and M13); cosmids; Phagemids; Binary (Ti plasmid, Ri plasmid) and Shuttle vectors; BACs, YACs; - Construction and screening of genomic and c-DNA libraries. **Genetic trasformation in plants** - *Agrobacterium* mediated genetic engineering of plants, *Agrobacterium tumefaciens* infection and molecular mechanism of tumor formation. - Genetic transformation in plants by vector less methods.	**18 + 2 hrs**
Unit II	**Tools and Techniques** - PCR, its types (Conventional-PCR, Inverse-PCR, RT-PCR, Q-PCR) and its applications. - Southern, Northern and Western blotting techniques (Self-study) - **CRISPR**-cas9 – RNA-guided nuclease for genome editing - **DNA Sequencing** – Sanger sequencing, pyrosequencing, NGS, Nanopore Technology (4G) (Shifted from unit III) - DNA bar coding in plants. (Self study)	**8 + 3 hrs**

Unit III	**Applications of rDNA technology (specify examples)** - Secondary metabolite production through hairy root culture (Vincristine from *Vinca rosea*) - Disease resistance (Bt cotton) - Gene silencing in crop plants (Flavr savr tomato) - terminator seed technology. - Production of edible vaccine (TOMAVAC)	**7+1**
Unit IV	**Microbial biotechnology** **Enzyme biotechnology:** Isolation and purification of enzymes - Cellulase, Invertase, Pectinase. Immobilization of enzymes, uses of enzymes. **Uses of microbes in Industry and Agriculture:** Fermenters and bioreactors. Production of organic compounds by fermentation: acetone-butanol. Production of antibiotic: Penicillin and Streptomycin Production of SCP: *Spirulina* and *Chlorella* (Self-study) Biofertilizers and biocontrol agents: *Azospirillum, Rhizobium, Trichoderma.* Production of bioinsecticides: *Bacillus thuringiensis* and NPV	**14 +1 hr**
Unit V	**Nanobiotechnology** – Introduction, types of nanoparticles and nanomaterials, their green synthesis and its role in medical applications and Agriculture	**3 hours**
Unit VI	**Intellectual Property Rights** – Patent, Copyright, Trade Mark & Trade Secrets and their regulatory aspects. Biosafety and bioethics (Self-study).	**2 + 1 hrs**

List of experiments for practicals - BO 9P3: Biotechnology **TOTAL 44 HOURS**

1. Production of SCP: *Spirulina*/*Chlorella*
2. Wine production
3. Preparation of media and inoculation of explants with *Agrobacterium rhizogenes*.
4. Extraction and estimation of secondary metabolites produced by hairy root culture.
5. Isolation of plasmid DNA
6. Restriction digestion of DNA and agarose gel electrophoresis of restriction fragments
7. Purification of DNA from gel and its quantification by nano-spectrophotometer.
8. RAPD of genomic DNA
9. Preparation of competent *E. Coli* cells.
10. Transformation of *E. coli* competent cells with the plasmid containing GFP.
11. Revision

References:

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BLUEPRINT
Code number: BO 9324
Title of the paper: Biotechnology

Total marks for which the questions are to be asked (including bonus questions)	Number of hrs	Unit number
25	20	I
14	11	II
10	8	III
19	15	IV
4	3	V
4	3	VI
76	**60**	**TOTAL**
Maximum marks for the paper (Excluding bonus question): **50**		

Course Outcomes and Course Content

Semester	III
Paper Code	BODE 9424
Paper Title	Advanced Plant Physiology
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

- To get a comprehensive understanding of the mechanism of signal transduction in plants
- To understand photobiology and its significance
- To understand the mechanisms of abiotic stresses and its impact on plant physiology
- To comprehend the effect of biotic stress in plants, strategies in plants to overcome the same
- To apply these concepts to genetic engineering to develop resistant plant varieties

Unit I	**Photobiology** Phytochromes : discovery, structure, photochemical and biochemical properties, physiological function of phytochromes. Molecular mechanism of photoreceptor action. Cryptochromes : discovery, structure and physiological functions. *A brief account of phototropins and zeaxanthin (Self study)*	**7 hrs + 1 hr**
Unit II	**Signal Transduction** General overview, types of cell signaling, ligands/ cell signaling molecules, signaling receptors – characteristics, properties and structural classes. G- proteins and G-protein Coupled Receptors. Role of cyclic nucleotides as second messengers, Calcium signaling, Phospholipid signaling. A brief account of plant-to-plant communications.	**12 hrs**

Unit III	**Abiotic Stress** **Drought stress** – Causes. Effect of drought on physiological processes in plants, mechanisms of drought resistance in plants, anti- transpirants, drought hardening, molecular mechanism of drought stress. ABA and its role in stomatal guard cell signaling. **Flooding stress** – Causes, Physiological effects of flooding stress, anaerobiosis, Role of ethylene and its signalling pathway, tolerance mechanism. **Salt stress** – definition of saline soil, salinity and sodicity, cause of soil salinization, Physiological effects of salinity stress, tolerance mechanisms – role of antiporters, SOS1. **Thermal stress** – Heat stress, chilling and freezing stress. Physiological effects, mechanisms of high and low temperature tolerance, hardening. *Oxidative stress – Causes, effects and mechanisms of tolerance. Enzymatic and non-enzymatic antioxidant systems.Engineering of plants for abiotic stress tolerance (Self study)*	**21 + <u>4hrs</u>**
Unit IV	**Biotic stress** – Effect of fungal infection on plant metabolism, phytoalexins, biochemical mechanism of disease resistance and allelopathy. Plant wound signaling pathway *Engineering of plants for biotic stress tolerance (Self study).* Defense mechanism in plants- Structure, role and mode of action of secondary metabolites - terpenes, phenolic compounds and nitrogen containing compounds: alkaloids, *cyanogenic glycosides and non protein amino acids (self study)* as defense molecules.	**12 + <u>3 hrs</u>**

<u>BO 9P4:</u>

Total: 44 Hours
(11 Sessions 4hrs/Week)

1. Estimation of proteins in salt stressed plants, by Lowry-Lopez method.
2. Estimation of total carbohydrates in drought stress plants, by Phenol-sulphuric acid method
3. Estimation of proline in drought stressed plants.
4. Estimation of proline in salt stressed plants.
5. Estimation of soluble and insoluble phenolics in biotic stressed plants.
6. Estimation of leaf water content and relative electrical conductivity in drought stressed plants.
7. Estimation of activity of the enzyme super oxide dismutase (SOD) in salt stressed plants.
8. Estimation of ascorbic acid in drought stressed plants.
9. Estimation of activity of catalase in salt and drought stressed plants.
10. Estimation of activity of peroxidase in salt and drought stressed plants.
11. Revision

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BLUE PRINT

Code number: BODE9424

Title of the paper: Advanced Plant Physiology

Total marks for which the questions are to be asked (including bonus questions)	Number of hrs	Chapter/ Unit number
10	8	I
15	12	II
32	25	III
19	15	IV
76	**60**	**TOTAL**
Maximum marks for the paper (Excluding bonus question): **50**		

Course outcomes: At the end of the course, the student

CO1	Will be able to understand and appreciate the complex mechanisms of signal transduction in plants
CO2	Will be able to enumerate the processes in photobiology including its receptors and its significance
CO3	Will be able to explain the mechanisms of abiotic stresses and its impact on plant physiology
CO4	Will be able to comprehend the effect of biotic stress in plants, strategies in plants to overcome the same
CO5	Will be able to apply these concepts to genetic engineering to develop resistant plant varieties

Course Outcomes and Course Content

Semester	**III**
Paper Code	**BODE 9524**
Paper Title	**Plant Tissue Culture**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

To understand the basic principles of Plant Tissue Culture
To understand various culture techniques in Plant Tissue Culture
To develop hands-on skills in various instrumentation
To nurture research attitude & applications towards Plant Tissue Culture

Unit I	A brief account of principles and history of plant tissue culture. Contributions of Haberlandt, White, Morel, Murashige and Skoog. Terminology-Totipotency, explant, callus, differentiation, dedifferentiation, redifferentiation, cytodifferentiation, xylogenesis, rhizogenesis, embryogenesis, meristemoid, protocorm like bodies, organogenesis (direct and indirect).	1hr + 2 *hrs*
Unit II	Organization of plant tissue culture laboratory: Requirements of plant tissue culture lab-preparation room, inoculation chamber and growth room. Instrumentation- Laminar air flow, autoclave, hot air oven, steripot, pH meter, electronic balance, rotary shakers, magnetic stirrer, distillation unit and glassware.	9 + 1hrs
Unit III	Role of plant growth regulators in Plant tissue culture-Auxins (NAA, IBA, 2,4-D), cytokinins (Kinetin, BAP, Zeatin, TDZ), Gibberellins (GA3), and Abscisic Acid. Effect of Auxin-cytokinin ratio.	3 hrs
Unit IV	Plant tissue culture techniques: Preparation of nutrient media, selection of explants, surface sterilization of plant material, inoculation of explants. Maintenance of cultures *in vitro*. Growth room conditions and hardening techniques.	8 hrs
Unit V	Organ culture and its applications: Meristem, shoot tip, leaf, axillary bud, flower bud, root, ovule, ovary, embryo, anther and pollen cultures	8 hrs

Unit VI	Principles, techniques and applications of protoplast culture. Isolation and culture of protoplasts. Role of cellulase and pectinase. Properties of isolated protoplasts. Protoplast fusion and somatic hybridization - spontaneous fusion, induced fusion, mechanical fusion, chemo-fusion, electro-fusion. Mechanism of protoplast fusion, hybrid identification, hybrid isolation and post-fusion events. Somaclonal variations and importance of somatic hybridization, somatic hybrids and cybrids.	10 hrs
Unit VII	Indirect methods of gene transfer: *Agrobacterium (A. tumefaciens and A. rhizogenes*) mediated gene transfer. Direct methods of gene transfer: Micro projectile/particle Bombardment (biolistics), Electroporation, Microinjection, Chemical mediated gene transfer, Liposome mediated gene transfer and Silicon carbide method	8 hrs
Unit VIII	Germplasm storage and cryopreservation: Germplasm resources, Genebanks, Types and Methods of Conservation, slow growth media, Cryopreservation Techniques, revival of cryoprotected materials, Advantages and Limitations	4 hrs
Unit IX	Application of plant tissue culture in clonal propagation, agriculture, horticulture and forestry. *In vitro* production of secondary metabolites.	4+2 hrs

Blueprint

Code number: **BODE 9524**
Title of the paper: **Plant Tissue Culture**

Total marks for which the questions are to be asked (including bonus questions)	**Number of Hours**	**Unit Number**
4	3	I
12	10	II
4	3	III
10	8	IV
10	8	V
13	10	VI
10	8	VII
5	4	VIII
8	6	IX

76	60	TOTAL
Maximum marks for the paper (Excluding bonus question): **50**		

BO 9P5: Plant Tissue Culture Elective

Total: 44 hours

1. Introduction to laboratory equipment's & sterilization.
2. MS stock and media preparation.
3. Explant preparation and inoculation of explant.
4. Organ culture - Leaf, node, meristem, anther and ovary
5. Callus culture and suspension culture
6. Micro propagation of orchid seeds.
7. Micro propagation of Banana.
8. Protoplast isolation and its culture.
9. Sub culture technique and Hardening techniques
10. Production of synthetic seeds.
11. Revision.

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Course Outcomes: At the end of the Course, the Student

CO1	oriented skill development to work in commercial plant tissue culture laboratory
CO2	ganization and Design of commercial plant tissue culture laboratory
CO3	chniques in production of commercial important plants

Course Outcomes and Course Content

Semester	**III**
Paper Code	**BODE 9624**
Paper Title	**Microbiology**
Number of teaching hours per week	**04**
Total number of teaching hours per semester	**60**
Number of credits	**04**

Objective of the Paper: At the end of semester students should be able

- To understand the importance of microbes in agriculture, industries and environment
- To be able to describe the pathogens and diseases caused by them
- To be able to understand the mechanism of immune system and its functions
- To be able to illustrate the mechanism of action of antibiotics and drug resistance in microorganisms

Unit I : Applied Microbiology		**(30hrs)**
Chapter No. 1	**Soil & Agricultural Microbiology** Soil Microflora: Distribution and Diversity of Soil Microflora. Rhizosphere, Rhizoplane, Mycorrhizosphere and Actinomycetes. Molecular mechanisms in nitrogen fixation. Biodegradation of Cellulose, Pectin, Chitin, Lignin, Plastic and Xenobiotics. *Mechanism of Humus formation and its role in agriculture.* Brief account on role of endophytes as growth regulators	**12hrs** (10hrs + *2hrs*)
Chapter No. 2	**Industrial Microbiology** Introduction to Fermentation Technology Bioreactors, Media and Inoculum Preparation. Temperature and pH regulation and product recovery techniques. Production of Steroids and Riboflavin. Production of Enzymes: Amylase Proteases and Lipases. Production of Organic Acids: Lactic acid, acetic acid & Citric acid *Production of Alcohol: Ethanol*	**11hrs** (10hrs + *1hr)*

Chapter No. 3	**Food & Dairy Microbiology** Microbiology of Milk & Milk Products Microorganisms in Milk, Milk Borne Pathogens, Bacteriological Tests in Milk, Milk Grading. Pasteurization & Sterilization. *Microbial Spoilage & Preservation of Food & Food Grains* Bacterial Food Poisoning: Prevention & Control Measures	**7hrs** (6hrs + *1hr*)
Unit II : Environmental Microbiology		**(8hrs)**
Chapter No. 4	**Environmental Microbiology** Aquatic Microbiology: Role of microbes in water quality Microbes in Sewage Treatment: *Water Treatment, Sewage Treatment,* Biofilms: Fixed film & Suspended film Sewage Treatment System. Role of microbes in composting of solid waste, Bioremediation of pollutants: Industrial and hazardous waste, Oil Spills, Heavy metals, Pesticides,	**8hrs** **(**6hrs + *2hrs*)
Unit III : Medical Microbiology		**(22hrs)**
Chapter No. 5	Etiology, symptoms & prevention and treatment of disease caused by following **Bacteria**: *Streptococcus sp. Clostridium sp. Corynebacterium diphtheria Mycobacterium tuberculosis, Neisseria gonorrhea*, Brief account of *Escherichia coli, Vibrio cholera*) **Viruses:** Hepatitis virus, Human Papilloma Virus, H1N1 virus, Dengue virus, Nipah virus, HIV, SARS CoV, Brief account of Polio virus, Chicken pox virus, **Any 4 pathogens can be given for self study*	**12hrs** (10hrs + 2*hrs*)
Chapter No. 6	**Immunology** Antibody Diversity (VDJ Recombination) Antigen-Antibody Interactions Inflammation & Fever, Hypersensitive Reactions Monoclonal Antibodies: Production & Significance Antimicrobial Drugs: Mechanism of action on Cell wall, Protein, Nucleic acid, essential metabolites biosynthesis Antibiotic Drug Resistance.	**10 hrs**

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Blueprint

Paper Code: **BODE 9624**
Title of the paper: **Microbiology**

Total marks for which the questions are to be asked (including bonus questions)	**Number of Hours**	**Unit Number**
38	30	I
10	08	II
28	22	III
76	**60**	**TOTAL**
Maximum marks for the paper (Excluding bonus question): **50**		

BO 9P6: Microbiology

Total: 44 hours

1. Isolation of microbes from Rhizospheric, Rhizoplane soil
2. Isolation of *Rhizobium* bacteria from root nodules of pulses
3. Isolation of microbes from milk and milk products
4. Study of bacterial growth curve
5. Endospore, Capsule and Fungal staining
6. Bacteriological Examination of Water: Quantitative Estimation by Serial Dilution Method
7. Biochemical Characterization of Microbes –I (Carbohydrate fermentation, Esculin hydrolysis, TSI, and IMVIC)
8. Biochemical Characterization of Microbes –II (Catalase, Urease, Nitrate, and Starch hydrolysis)
9. Antibiotic Sensitivity Test (AST)
10. Biodegradation of dyes by microbes
11. Study of Anaerobic Bacteria by using Anaerobic Jar/ Thioglycolate broth

Course Outcomes: At the end of the Course, the Student

CO1	Have developed understanding on uses of microbes in Industries & Agriculture
CO2	Have developed basic microbiology skills to isolate microbes from various sources
CO3	Have learnt how to test quality of food and food products
CO4	Have learnt the significance of microbes in diseases and its treatment options
CO5	Have learnt the role of immune system and inferences of immune reactions

Course Outcomes and Course Content

Semester	**III**
Paper Code	**BODE 9724**
Paper Title	**Systematics of Angiosperms**
Number of teaching hours per week	04
Total number of teaching hours per semester	60
Number of credits	04

Objective of the Paper:

To understand importance naming plants
To understand importance role of applied aspects in taxonomy in plant nomenclature.
To understand significance of modern techniques in relation to systematics
To infer the phylogenetic relationships of plant groups and to use that pattern of evolutionary history to assess aspects of character evolution, biogeography, ecology, and evolutionary process;
To investigate the delimitation of plant species and infraspecies

Course Outcomes: At the end of the Course, the Student will be able

CO1	To describe the classification through morphology. To describe plant classification by using advanced knowledge from Anatomy, Palynology, Embryology, Cytology and Chemosystematics.
CO2	To understand the fundamentals of plant systematics and its various concepts
CO3	Solve problems involving taxonomic keys and nomenclatural problems.
CO4	Evaluate the validity of theoretical classification based on experimental evidence.
CO5	Critique experimental methodologies and data analysis techniques used in taxonomic and systematics research.
CO6	Develop theoretical models to explain observed morphological characteristic features, Anatomy, Palynology, Embryology, Cytology and Chemosystematics characteristic features in plant systematics.

Unit I	Comparative study of Classifications (Bessey, Dahlgren and Thorne), Angiosperm Phylogeny Group (I-IV)	**3+3 hrs**
Unit II	Terms and concepts: Primitive, advanced; homology, analogy; parallelism, convergence; monophyly, paraphyly	**16 hrs**
	Origin and evolution of angiosperms: Time of origin of angiosperms; Probable ancestors of angiosperms - Pseudanthial Theory, Euanthial Theory – Caytoniales, Bennettitales, Herbaceous Origin Theory, Transitional-Combinational Theory; Fossil record of early angiosperms; Basal angiosperms (the ANA grade); Ancestral flower of angiosperm; Co-evolution of angiosperms and animals	
Unit III	Evolution and Differentiation of Species: Abrupt and gradual speciation, races, species, Deme terminology. Isolating mechanisms: geographical and ecological, seasonal and	**8+2hrs**

	temporal, mechanical and ethological isolation; hybridization and speciation; stabilization of hybrids	
Unit IV	Species concept: Nominalistic, typological, biological, ecological and evolutionary concepts	**8+1 hrs**
	Clausen's experiment, Turresson's experiment, ecotypic variation, ecotypes and ecad.	
Unit V	Databases in Systematics: Plant identification packages; storage and retrieval of herbarium specimen information; electronic herbarium; open ended floras, computer-based mapping of plant distribution and vegetation change; Cladistics: cluster analysis, construction of phenograms and cladograms (SimpleClade and PHYLIP); websites related to plant systematics (JCB)	**8+2 hrs**
Unit VI	Modern Systematics (a brief idea) - Utility and limitations of the following: ultrastructural characters; methods of protein analysis and protein data; immunological data. Methods of obtaining and utilizing data from nucleic acids in phylogenetic evaluation; DNA barcoding - plant DNA barcoding markers; basic steps in DNA barcoding; applications of DNA barcoding; limitations of DNA barcoding; DNA barcoding and traditional taxonomy.	**9 hrs**

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Practicals BO 9P7

LABORATORY WORK

1. Collection and documentation of flowering plants (SJU campus Flora)
2. Construction of artificial dichotomous keys (Bracketed) of the plants.
3. Construction of artificial dichotomous keys (Intended) of the plants.
4. Identification of flowering plants using Floras.
5. Solution of selected nomenclatural problems with the help of ICN.
6. Solution of selected nomenclatural problems with the help of ICN.
7. Construction of phylogenetic tree using SimpleClade,
8. Construction of phylogenetic tree using Phylip.
9. Histological studies in understanding the localization of secondary metabolites
10. Estimation of pigments and analysis using spectrophotometer

The students should be taken to any one of the following:
A protected area viz., National Park / Sanctuary / Biosphere reserve / Botanical gardens / Research institutes / museum.

Blueprint

Code number: **BODE 9724**
Title of the paper: **Systematics of Angiosperms**

Total marks for which the questions are to be asked (including bonus questions)	**Number of Hours**	**Unit Number**
8	06	I
21	16	II
12	10	III
11	09	IV
13	10	V
11	09	VI
76	**60**	**TOTAL**
Maximum marks for the paper (Excluding bonus question): **50**		