University of Mumbai

No. AAMS_UGS/ICC/2024-25/154

CIRCULAR:-

Attention of all the Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Departments is invited to this office Circular No. AAMS_UGS/ICC/2023-24/23 dated 08th September, 2023 relating to the NEP UG & PG Syllabus.

They are hereby informed that the recommendations made by the **Board of Studies in Botany** at its meeting held on 31st August, 2024 and subsequently passed by the Board of Deans at its meeting held on 3rd September, 2024 **vide** item No. 6.11 (N) have been accepted by the Hon'ble Vice Chancellor as per the power confirmed upon him under section 12(7) of the Maharashtra Public Universities Act, 2016 and that in accordance therewith syllabus for **M.Sc. (Botany) Sem – III & IV** is introduced as per appendix (NEP 2020) with effect from the academic year 2024-25.

(The Circular is available on the University's website www.mu.ac.in).

(Dr. Prasad Karande)
REGISTRAR

MUMBAI – 400 032
21st September, 2024

To

All the Principals of the Affiliated Colleges, Directors of the Recognized Institutions and the Head, University Departments.

BOD 6.11(N) 03/09/2024

Copy forwarded with Compliments for information to:-

1) The Chairman, Board of Deans,
2) The Dean, Faculty of Science,
3) The Chairman, **Board of Studies in Botany**
4) The Director, Board of Examinations and Evaluation,
5) The Director, Department of Students Development,
6) The Director, Department of Information & Communication Technology,
7) The Director, Centre for Distance and Online Education (CDOE) Vidyanagari,
8) The Deputy Registrar, Admission, Enrolment, Eligibility & Migration Department (AEM),

Copy forwarded for information and necessary action to :-	
1	The Deputy Registrar, (Admissions, Enrolment, Eligibility and Migration Dept)(AEM), dr@eligi.mu.ac.in
2	The Deputy Registrar, Result unit, Vidyanagari drresults@exam.mu.ac.in
3	The Deputy Registrar, Marks and Certificate Unit,. Vidyanagari dr.verification@mu.ac.in
4	The Deputy Registrar, Appointment Unit, Vidyanagari dr.appointment@exam.mu.ac.in
5	The Deputy Registrar, CAP Unit, Vidyanagari cap.exam@mu.ac.in
6	The Deputy Registrar, College Affiliations & Development Department (CAD), deputyregistrar.uni@gmail.com
7	The Deputy Registrar, PRO, Fort, (Publication Section), Pro@mu.ac.in
8	The Deputy Registrar, Executive Authorities Section (EA) eau120@fort.mu.ac.in He is requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to the above circular.
9	The Deputy Registrar, Research Administration & Promotion Cell (RAPC), rapc@mu.ac.in
10	The Deputy Registrar, Academic Appointments & Quality Assurance (AAQA) dy.registrar.tau.fort.mu.ac.in ar.tau@fort.mu.ac.in
11	The Deputy Registrar, College Teachers Approval Unit (CTA), concolsection@gmail.com
12	The Deputy Registrars, Finance & Accounts Section, fort draccounts@fort.mu.ac.in
13	The Deputy Registrar, Election Section, Fort drelection@election.mu.ac.in
14	The Assistant Registrar, Administrative Sub-Campus Thane, thanesubcampus@mu.ac.in
15	The Assistant Registrar, School of Engg. & Applied Sciences, Kalyan, ar.seask@mu.ac.in
16	The Assistant Registrar, Ratnagiri Sub-centre, Ratnagiri, ratnagirisubcentar@gmail.com
17	The Director, Centre for Distance and Online Education (CDOE), Vidyanagari, director@idol.mu.ac.in
18	Director, Innovation, Incubation and Linkages, Dr. Sachin Laddha pinkumanno@gmail.com
19	Director, Department of Lifelong Learning and Extension (DLLE), dlleuniversityofmumbai@gmail.com

Copy for information :-	
1	P.A to Hon'ble Vice-Chancellor, vice-chancellor@mu.ac.in
2	P.A to Pro-Vice-Chancellor pvc@fort.mu.ac.in
3	P.A to Registrar, registrar@fort.mu.ac.in
4	P.A to all Deans of all Faculties
5	P.A to Finance & Account Officers, (F & A.O), camu@accounts.mu.ac.in

To,

1	The Chairman, Board of Deans pvc@fort.mu.ac.in
2	**Faculty of Humanities,** **Dean** 1. Prof.Anil Singh Dranilsingh129@gmail.com **Associate Dean** 2. Dr.Suchitra Naik Naiksuchitra27@gmail.com 3.Prof.Manisha Karne mkarne@economics.mu.ac.in
	Faculty of Commerce & Management, **Dean** 1. Dr.Kavita Laghate kavitalaghate@jbims.mu.ac.in **Associate Dean** 2. Dr.Ravikant Balkrishna Sangurde Ravikant.s.@somaiya.edu 3. Prin.Kishori Bhagat kishoribhagat@rediffmail.com

	Faculty of Science & Technology **Dean** 1. Prof. Shivram Garje ssgarje@chem.mu.ac.in **Associate Dean** 2. Dr. Madhav R. Rajwade Madhavr64@gmail.com 3. Prin. Deven Shah sir.deven@gmail.com
	Faculty of Inter-Disciplinary Studies, **Dean** 1.Dr. Anil K. Singh aksingh@trcl.org.in **Associate Dean** 2.Prin.Chadrashekhar Ashok Chakradeo cachakradeo@gmail.com
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4	The Director, Board of Examinations and Evaluation, dboee@exam.mu.ac.in
5	The Director, Board of Students Development, dsd@mu.ac.in@gmail.com DSW direcotr@dsw.mu.ac.in
6	The Director, Department of Information & Communication Technology, director.dict@mu.ac.in

BOD – 3/9/2024
12 (7) of M.P.U.A. 2016
Item No. – 6.11 (N)

As Per NEP 2020

University of Mumbai

Title of the P.G. program
M.Sc. (Botany)

Syllabus for

Semester – Sem.- III & IV
Ref: GR dated 16th May, 2023 for Credit Structure of PG

(With effect from the academic year 2024-25)

University of Mumbai

(As per NEP 2020)

Sr. No.	Heading	Particulars
1	**Title of program** **O:_____ B**	**M.Sc. (Botany)**
2	**Scheme of Examination** **R: _____**	**NEP** **50% Internal** **50% External,** **Semester End Examination** **Individual Passing in Internal and External Examination**
3	**Standards of Passing** **R: _____**	**40%**
4	**Credit Structure** **R: SP – 70 B**	**Attached herewith**
5	**Semesters**	**Sem. III & IV**
6	**Program Academic Level**	**6.5**
7	**Pattern**	**Semester**
8	**Status**	**New**
9	**To be implemented from Academic Year**	**2024-25**

Sign of the BOS Chairman
Dr. Vasant Mali
BoS (Botany)

Sign of the Offg. Associate Dean
Dr. Madhav R. Rajwade
Faculty of Science & Technology

Sign of the Offg. Dean
Prof. Shivram S. Garje
Faculty of Science & Technology

Preamble

1) Introduction

The MSc Part II syllabus has been designed as per the objectives and guidelines of National Education Policy 2020. The second year of the Master of Science program in Botany has five specializations: Angiosperms and Phytochemistry, Ecology and Environment, Mycology and Plant Pathology, Molecular Biology, Cytogenetics and Biotechnology, Plant Physiology and Plant Biochemistry.

In Angiosperms and Phytochemistry, students embark on an enriching academic journey delving into the intricate world of plant biology. This specialization represents a convergence of two key areas of botanical research, offering unique insights into the fundamental aspects of plant life. Through rigorous coursework and laboratory exercises, students gain a profound understanding of angiosperm taxonomy, evolution, ecology, and biogeography, as well as plant systematics and biodiversity conservation. Complementing the study of angiosperms is a focused exploration of phytochemistry, examining the chemical composition and properties of plant compounds. Students delve into biosynthetic pathways, pharmacological properties, and potential applications in medicine, agriculture, and industry.

In Ecology and Environment, students will be made aware of Ecosystem and habitat, Biogeochemical cycles, Climate change and environment degradation, Sustainable development, Biodiversity, Waste management, Pollution, Population dynamics, Management of Indian Coastal Zone, Conservation & Remediation. The syllabus emphasizes on use of biotechnology to deal with environmental issues, social aspects so that the students can be responsive citizens.

Mycology and Plant Pathology explores the diversity of fungi and fungal pathogens. The syllabus makes the students aware of the positive and negative effects of fungi, preventive measures to deal with fungal plant diseases. The syllabus focuses on developing the analytical skills of students for mycoremediation, production of biofuels, production of pharmaceutical products using fungal biotechnology.

This course provides students with a comprehensive understanding of Molecular biology, Cytogenetics and Biotechnology in plant sciences. Students will explore fundamental and advanced knowledge, focusing on practical applications in plant tissue culture and genetic engineering. Emphasizing biotechnological innovations, the course addresses global challenges in food security, sustainable agriculture, and environmental conservation.

Students will also develop proficiency in biostatistics and bioinformatics for analyzing complex biological data. They will further develop critical thinking and problem-solving skills essential for independent research and scientific advancement. The course aims to prepare students for competitive exams, careers in academia, industry, and entrepreneurship by combining theoretical knowledge with practical experience.

Additionally, the course explores the impact of biotechnology in industrial, food, and environmental contexts and developing solutions that contribute to the global ecosystem.

The course Plant Physiology and Plant Biochemistry develops the students' understanding of physiological aspect of translocation and stress in plants, and role of enzymes in plant metabolism. It also enhances the students' knowledge about the processes like photosynthesis and respiration in plants. The syllabus helps in upscaling the students' proficiency in practical handling of the physiological and biochemical aspect.

The syllabus also deals with practical use of modern day instruments and Biostatistics in the physiological and biochemical analysis of plant.

All the specializations provide additional support via different electives subjects so as to bring all round development of the students and make them self reliant and employable.

2) Aims and Objectives

a. Impart National Education Policy based education to the students.
b. Develop practical, and research aptitude of the students.
c. Enhance the reasoning, analytical skills of the students.
d. Promote the understanding of all the aspects of plant growth and development with respect to environment.
e. Enhance understanding of the physiology, biochemistry and genetics of plant and application of biotechnology to improve the plant diversity.

3) Learning Outcomes

Students will be able to:

a. Identify and classify plant species based on morphological, anatomical, molecular, and genetical characteristics.
b. Identify and analyze the chemical constituents of plants and understand their roles and applications in various fields such as medicine, agriculture, and industry.
c. Interpret the ecological interconnections of life processes on earth by studying ecological principles and nutrient flow through the environment.
d. Explain the theory of evolution with scientific explanations about diversity of life on earth.
e. Design and execute research projects employing appropriate scientific methodologies.
f. Integrate traditional methods with contemporary molecular and biochemical techniques to enhance the accuracy and scope of their research.
g. Identify the fungal pathogen affecting the crop plants, understand the disease cycle and devise strategies to control the plant disease and suggest preventive measures.
h. Apply the principles and practices of medical mycology, focusing on the diagnosis, treatment, and prevention of fungal diseases in humans and animals.
i. Design protocols for mycoremediation, production of biofuels, production of pharmaceutical products using fungal biotechnology,
j. Contribute to conservation efforts by identifying and documenting plant and microbial species and understanding their ecological significance.
k. Apply ethical principles in their research and promote sustainability in the use of plant biodiversity.
l. Understand the physiological and biochemical processes occurring in plants.

m. Analyse the external and internal factors affecting plant growth and development.
n. Gain a comprehensive understanding of fundamental concepts in Plant Biotechnology, Cytogenetics and Molecular Biology, and explore their applications in the recent research and biological systems
o. Apply the biostatistics and bioinformatic principles in research and data analysis and interpret complex biological data to draw meaningful conclusions.
p. Develop proficiency in plant tissue culture, genetic engineering and plant breeding and explore Bio-nanotechnology, Industrial, Food and Environmental Biotechnology to benefit society and foster entrepreneurial skills.
q. Demonstrate proficiency in the experimental techniques, instrumentation and methods of analysis appropriate for understanding the above.
r. Develop critical and logical thinking and prepare the student to excel in competitive exams such as UPSC, MPSC, CSIR and UGC NET; writing research proposals.

4) Credit Structure of the Program (Sem III & IV)

Post Graduate Programs in University Parishishta - 1

R: SP – 70 B									
Exit option: PG Diploma (44 Credits) after Three Year UG Degree									
II	**6.5**	**Sem III**	Course 1 Credits 4 Course 2 Credits 4 Course 3 Credits 4 Course 4 Credits 2	**Credits 4** Course 1 OR Course 2 OR			4	22	**PG Degree After 3-Yr UG**
		Sem IV	Course 1 Credits 4 Course 2 Credits 4 Course 3 Credits 4	**Credits 4** Course 1 OR Course 2 OR			6	22	
Cum. Cr. for 1 Yr PG Degree			**26**	**8**			**10**	**44**	
Cum. Cr. for 2 Yr PG Degree			**54**	**16**	**4**	**4**	**10**	**88**	

Note: * The number of courses can vary for totaling 14 Credits for Major Mandatory Courses in a semester as illustrated.

Outline of the Course:

PSBO: IPR and Entrepreneurship skills (Common Paper for all Specializations)

Specializations

1. Angiosperms and Phytochemistry (ANP)
2. Environmental Botany (EB)
3. Mycology and Plant Pathology (MPP)
4. Molecular Biology, Cytogenetics and Biotechnology (MCB)
5. Plant Physiology and Biochemistry (PPB)

Semester III

Theory		Credits
Course 1	PSBO:	4
Course 2	PSBO:	4
Course 4	PSBO:	2
Open Elective	PSBO: From Specialization **OR**	2+2
Open Elective	PSBO: From other Specialization	
Practicals – Course 3 (based on Course 1 and 2):	PSBOP, PSBOP,	2+2
Research Project		4
Total		22

SEM IV

Outline

Specializations

1. Angiosperms and Phytochemistry (ANP)
2. Environmental Botany (EB)
3. Mycology and Plant Pathology (MPP)
4. Molecular Biology, Cytogenetics and Biotechnology (MCB)
5. Plant Physiology and Biochemistry (PPB)

Theory	Credits
Course 1 PSBO:	4
Course 2 PSBO:	4
Open Elective PSBO: **OR**	2+2
Open Elective PSBO:	
Practicals – Course 3 (based on Course 1 and 2): PSBOP, PSBOP,	2+2
Research Project	6
Total	22

Angiosperms and Phytochemistry (Specialization 1)

Exit option: PG Diploma (44 Credits) after Three Year UG Degree									
II	**6.5**	**Sem III**	Course 1 **Basics of Angiosperm Taxonomy** Credits 4 Course 2 **Phytochemistry in Angiosperm Taxonomy** Credits 4 Course 3 **Practicals based on Course I & II** Credits 4 (2+2) Course 4 **IPR and Entrepreneurship skills** Credits 2	**Credits 4 (2+2)** Course 1 **Biodiversity: Conservation and Preservation** OR Course 2 **From other Specialization**			4	22	**PG Degree After 3-Yr UG**
		Sem IV	Course 1 **Trends in Angiosperm Taxonomy** Credits 4 Course 2 **Trends in Phytochemistry** Credits 4 Course 3 **Practicals based on Course I & II** Credits 4 (2+2)	**Credits 4 (2+2)** Course 1 **Biodiversity and Ecotextile** OR Course 2 **From other Specialization**			6	22	
Cum. Cr. for 1 Yr PG Degree			**26**	**8**			**10**	**44**	
Cum. Cr. for 2 Yr PG Degree			**54**	**16**	**4**	**4**	**10**	**88**	

Sem. - III

COURSE CODE	TITLE AND LEARNING OUTCOMES
PSBO	**Basics of Angiosperm Taxonomy** **LEARNING OUTCOMES:** Students will be able to • demonstrate knowledge of the diversity of angiosperms, including major families, genera, and species. • understand the principles and methods of taxonomic classification used in angiosperm taxonomy, including morphological, molecular, and phylogenetic approaches. • identify angiosperm families, genera, and species using taxonomic keys, morphological characteristics, and other diagnostic features. • collect, preserve, and document plant specimens for taxonomic study, including fieldwork techniques and herbarium practices.
PSBO	**Phytochemistry in Angiosperm Taxonomy** **LEARNING OUTCOMES:** Students will be able to • understand the chemical diversity present in angiosperms, including the different classes of secondary metabolites such as alkaloids, flavonoids, terpenoids, and phenolics. • master the techniques used in phytochemical analysis, including extraction, isolation, purification, and characterization of plant compounds using methods such as chromatography, spectroscopy, and spectrometry. Taxonomic relationships among angiosperms. • identify and interpret phytochemical markers that are diagnostic for particular taxa or phylogenetic groups within angiosperms.
PSBO	**Practicals in Angiosperms and Phytochemistry** **LEARNING OUTCOMES:** Students will be able to • demonstrate knowledge of the diversity of angiosperms, including major families, genera, and species. • collect, preserve, and document plant specimens for taxonomic study, including fieldwork techniques and herbarium practices. • Master the techniques used in phytochemical analysis, including extraction, isolation, purification, and characterization of plant compounds using methods such as chromatography, spectroscopy, and spectrometry. taxonomic relationships among angiosperms.
PSBO	**Trends in Angiosperm Taxonomy** **LEARNING OUTCOMES:** Students will be able to • understand the intricate interactions between plants and their pollinators. • evaluate various conservation strategies. • discuss the implications of speciation and evolutionary studies for biodiversity conservation and management.
PSBO	**Trends in Phytochemistry** **LEARNING OUTCOMES:** Students will be able to • appreciate Indian Traditional Knowledge. • evaluate the pharmacological properties of crude drugs. • understanding of the selected medicinal plants within the categories of psychoactive, fumitories, masticatories, stimulants, adulterants, substitutes, and controversial drugs.
PSBO	**Practicals in Angiosperms and Phytochemistry** **LEARNING OUTCOMES:** Students will be able to

	• identify and describe the morphological and ecological adaptations of flowers pollinated by insects. • differentiate between psychoactive drugs, fumitories, masticatories, and stimulants based on their phytochemical profiles

Syllabus
M.Sc. (Botany)
Angiosperms and Phytochemistry (ANP)
(Sem.- III)

SEMESTER III

Course Code **PSBO (ANP)**	**Title of the Paper- Basics of Angiosperm Taxonomy Course No. 1**			
	1	**Approaches to Angiosperm Taxonomy**	4	**1**
	2	**Study of plant families**		**1**
	3	**Tools of Angiosperm Taxonomy**		**1**
	4	**Nomenclature**		**1**

Course Code	Topic	Credits
PSBO (ANP)	**Basics of Angiosperm Taxonomy**	**4**
MODULE 1	**Approaches to Angiosperm Taxonomy:** • Phenetic vs Phylogenetic system; Outline of APG IV system of classification • Biosystematics: Objective, Steps, and Categories; Biosystematics about classical taxonomy • Identification of plants- Morphological characters used in the identification	**1**
MODULE 2	**Study of Plant Families:** Study of plant families as per APG IV. Give distinguishing characters and mention the economic importance of selected plants belonging to these groups. Study affinity and interrelation in these groups. • **Malvales** (Malvaceae, Sterculiaceae, Tiliaceae, and Bombacaceae) • **Myrtales** (Combretaceae, Myrtaceae, Lythraceae, and Onagraceae) • **Solanales** (Convolvulaceae, Solanaceae)	**1**
MODULE 3	**Tools of Angiosperm Taxonomy** • Flora; Monograph and Revision; Use of Taxonomic databases • Role of Botanical Garden, Herbarium (include examples of Indian Virtual Herbarium), and Botanical Museum in taxonomic study • Botanical drawing and photography in documentation • Anatomy, Cytology, Palynology, Embryology, Chemotaxonomy, Ecology, SEM, TEM, Molecular techniques in solving taxonomic problems	**1**
MODULE 4	**Nomenclature** • Principles of ICN • Articles related to taxonomic category, Different types of names, Homonym & Isonym, Types & Typification - Lectotypification, Neotypification • Priority of names, Author citation, Effective and valid publication • Process of naming a novel species and new combination; name change	**1**

Course outcomes

The students will be able to:

CO1: understand the historical botanical exploration in Maharashtra, including key expeditions, discoveries, and contributions to plant taxonomy.

CO2: apply taxonomic databases, including Flora, Monographs, and Revisions, with a focus on leveraging resources such as the Indian Virtual Herbarium.

CO3: explore the phylogenetic relationships and evolutionary affinities between different plant families within the orders Malvales, Myrtales, and Solanales.

CO4: comprehend the nomenclature principles according to the International Code of Nomenclature for algae, fungi, and plants (ICN).

Course Code PSBO (ANP)	Title of the Paper - Phytochemistry in Angiosperm Taxonomy			Course No. II
	1	Physical Methods in Evaluating Crude Drugs	**4**	**1**
	2	Chemical methods in Evaluating crude drugs		**1**
	3	Monographs & API		**1**
	4	Instruments for plant drug analysis		**1**

Course outcomes

Students will be able to

CO1: evaluate crude drugs using physical and chemical methods.
CO2: refer and use pharmacopoeias, including the Indian Pharmacopoeia, Ayurvedic Pharmacopoeia of India (API), and Herbal Pharmacopoeia & Treatise along with Monographs.

CO4: utilize instruments in plant drug analysis.

Course Code	Title	Credits
PSBO (ANP)	**Phytochemistry in Angiosperm Taxonomy**	**4**
Module 1	**Physical Methods in Evaluating Crude Drugs** • Organoleptic evaluation: • Microscopic characterization Leaf constants: o Palisade ratio and vein islet number. o Trichomes and its types; Trichome density o Stomata and its types, stomatal frequency & stomatal index. • Physico-chemical constants: o Ash Values: Total ash, acid-insoluble ash, Water soluble ash o Extractive values using polar; mid-polar & non-polar solvents (Water/Ethanol; Ethyl acetate/Methanol; Hexane/Chloroform) o Moisture content o Fluorescence analysis of plant drugs	**1**
Module 2:	Chemical Methods in Evaluating Crude Drugs • Qualitative chemical analysis: Preliminary Phytochemical and Histochemical analysis for primary and secondary phytochemicals • Quantitative chemical analysis: Quantification methods for o Phenols o Alkaloids o Essential oils	1

Module 3:	Monographs & API: • Pharmacopoeia: Indian Pharmacopoeia; Ayurvedic Pharmacopoeia of India (API); Herbal Pharmacopoeia & Treatise • Monographs and Types of Monographs • Knowledge of ethnobotany & herbal pharmaceutical industry • Monographs: o *Saraca asoka* o *Glycirrhiza glabra* o *Brahmi* o Bhui amla o Safed musli	1
Module 4:	Instruments for plant drug analysis: • Chromatography in plant drug analysis: TLC; HPLC; HPTLC; GC • Spectrophotometry - MS • Fingerprinting: Chemical and Molecular methods	1

Course Code PSBOP (ANP)	Title of the Paper- Practicals based on Course I & II			Course No. III
	I	Practicals based on Course I	2	1
	II	Practicals based on Course II		1

Course Outcomes: Student will be able to

CO1: identify the speciation processes from India, particularly Maharashtra, and understand the significance of endemism, keystone species, flagship species, and biodiversity hotspots in India, with a specific focus on plant endemism in the Western Ghats.
CO2: apply biosystematics principles, including objectives, steps, and categories, to the study of plant taxonomy, and understand its relationship with classical taxonomy.
CO3: demonstrate competence in quantitative chemical analysis, specifically in the quantification of phenols, alkaloids, and essential oils using appropriate methods and techniques.
CO4: develop expertise in fingerprinting techniques, encompassing both chemical and molecular methods, to authenticate and assess the quality of plant-derived products

Course Code	Title	Credits
PSBOP (ANP)	Practicals based on Course I	2
External:		1

1. Write a morphological description and morphometry of any two plants belonging to the families studied from FY – MSc part II. Prepare qualitative and quantitative data for analysis using Excel
2. Study of plant families as per APG IV. Give distinguishing characters and mention the economic importance of selected plants belonging to these groups. Give floral formula & Floral diagram for each
   - **Malvales** (Malvaceae, Sterculiaceae, Tiliaceae, and Bombacaceae)
   - **Myrtales** (Combretaceae, Myrtaceae, Lythraceae, Onagraceae)
   - **Solanales** (Convolvulaceae, Solanaceae)
3. Prepare an artificial key at the Family, Genus, and Species level using at least 20 plants belonging to the families studied from FY – MSc part II.
4. Problems based on Nomenclature - Any 3
5. Prepare a smear using suitable material to find chromosome number during metaphase, study the chromosome morphology, and categorize using Levan (1964) and Stebbins (1971).
6. Preparation of species distribution map of any study area (for one species) using QGIS

Internal:

1. Write a Floristic survey report for the purpose of submission to any funding authority
2. Collect at least 10 specimens of commonly available plants from your college campus, prepare a herbarium voucher; Prepare a Catalogue of voucher specimens to submit to your Herbarium.
3. Pressing of plants using dry preservation method for:
   i. Plant material of deciduous nature;

ii. Pressing of delicate plants using a reverse mounting technique; iii. Pressing of very large specimens 4. Wet Preservation of delicate plant parts for anatomical study, and palynological study. 5. Fixation of plant material for anatomical and karyological study. 6. UPGMA Cluster analysis using morphological data suitable software. (PAST, SPSS, or R software) 7. Enlist commonly available monsoon vegetables from any 3 local markets around you and compare the availability, market price, and demand for all these vegetables 8. Prepare a set of jewellary using seed and any other suitable plant material. Price it, and advertise. Make a start-up plan.	

PSBOP (ANP)	Practicals based on Course II	Credits: 2

External:

1. Macroscopic & Microscopic evaluation of crude drugs.
2. Study different types of stomata and Trichomes from herbal leaf samples.
3. Determine the stomata index and Stomatal number from the given leaf drug.
4. Calculate the Palisade ratio for the given leaf drug.
5. Determine the vein islet number for the given leaf drug.
6. Determine trichome density from the given leaf drug.
7. Determine the extractive value for the given herbal drug using polar, midpolar, and non-polar solvents
8. Check the authenticity of the plant crude drug by fluorescence analysis.
9. Conduct preliminary Phytochemical screening for Primary and Secondary metabolites. (TLC to be performed wherever necessary)
10. Carry out Histochemical screening detecting the presence of primary and secondary metabolites.
11. Conduct preliminary Phytochemical screening for Primary and Secondary metabolites. (TLC to be performed wherever necessary)

1

Internal:

1. Determine the total ash content of the given herbal sample and compare the same with the Indian/ Ayurvedic pharmacopoeia
2. Determine Acid-insoluble ash content for the given herbal drug and compare the same with the Indian/ Ayurvedic pharmacopoeia.
3. Determine water soluble ash content for the given herbal drug and compare the same with the Indian/ Ayurvedic pharmacopoeia.
4. Analyse the impact of storage on the given drug sample by determination of moisture content.
5. Extraction and quantification of essential oils using steam/hydro distillation.
6. Quantification of total alkaloids from the given plant drug.
7. Determine Total Phenolic Content (TPC) and Total flavonoid content (TFC) for the given herbal sample.

(Open Elective) Title: Biodiversity: Conservation and Preservation **Course Code: PSBO (ANP)** **Course V**		
Course Code: PSBO (ANP)	**Title: Biodiversity: Conservation and Preservation**	**Credit: 2**
Module 1	**Biodiversity monitoring and assessment**: • Biodiversity act of India and related international conventions. • Estimating changes in biodiversity. • The future of biodiversity in Indian scenario • Hotspots of Biodiversity in India Synergies between Sustainable use of Biodiversity and Climate change	1
Module 2	• **Herbaria & Herbarium specimens –** Collection, Use protocols & Specimen handling guidelines • **Plant specimen Collecting & Preparation:** o Preparation of Plant specimen for deposit as herbarium voucher o Herbarium Labels o Collecting geographical data in the field o Collection techniques for different groups of plants o Legal considerations • **Collection, acquisition and set preparation** o Accession and filing o Accillary collections- Spirit, Wood, Sees and seed bank • **Organisation and maintenance of collection** o Organisation of families, genera & Species, etc. o Folder making o Specimen repair o Updating nomenclature o Pest control and fumigation	1

Course Outcomes:

On completion of the course students should be able to:

CO1: contribute to conservation planning efforts by providing scientifically sound recommendations based on biodiversity assessments.

CO2: design and implement biodiversity monitoring programs, including setting objectives, selecting methods, and analyzing results.

CO3: navigate and comply with legal requirements for collecting and transporting plant specimens.

CO4: organize herbarium specimens by families, genera, and species, using appropriate taxonomic frameworks.

	SEMESTER III Elective (Practical) Biodiversity: Conservation and Preservation	
PSBOP (ANP)	**External**	**Credits 2**
1	**Carry out a documentation** in your campus / from a given data, map the number of species found in your study area on Google earth pro. Use data from your own observation and accepted database to categorize the most commonly available species /rarely available species from your list as per Red List Category of IUCN.	
2	**Preserve a plant specimen using**: i. Pressing technique between folds of the paper ii. Microwave iii. Sand iv. Wet Preservation technique	
3	**Mount a Herbarium specimen** using the given plant specimen, make a label and attach it on the herbarium sheet	
4	**Make a sample specimen folder** (containing smaller/ minute parts of a flower) for the purpose of attaching it on the herbarium sheet	
5	**Write annotation slip** for (i.) a **wrongly identified** herbarium specimen, (ii.) **nomenclature correction**. (**Note:** Any one Herbarium vouchers should be provided to the students for each of these exercises)	
	Internal	
1	Make a seed bank of locally available native trees. Test the viability of the collected seeds and write a report.	
2	Study various pests (insect and fungus) that is generally found in any one of the known herbarium (that is listed in Index Herbarium) and document the methods to manage these pests.	
3	Make a set of greetings card (at least 6) or any other artefact using the pressed plants/ plant parts. Price it and write a tag line to sale it.	
4	Document the contribution of UG/ PG students or Ph.D. students / faculty from the University of Mumbai in documenting district flora/ state flora/ local flora of any area (selected by you) based on herbarium study. (physical study / virtual)	
5	Document the contribution of common public in biodiversity documentation from social media.	

Sem. - III

COURSE OUTCOMES

COURSE CODE PSBO (EB)	TITLE AND LEARNING OUTCOMES
	Students will understand and comprehend the basic concepts of the environment along with their interactions.
	Students will compare and differentiate between different types of habitats as well as interactions and understand the working of the environment
	Students will explain the different components of the ecosystem as well as the formation of the different landforms.
	Students will interpret the ecological interconnections of life processes on earth by studying ecological principles and nutrient flow through the environment. They will also relate the physical features of the environment to the structure of populations, community, and ecosystems.
	Students will not only understand the environmental pollution but also provide solutions for restoration of the environment.
	Students will provide solutions for coastal area management.

Course Code PSBO (EB)	**Title of the Paper- Environmental Botany and Recent Trends I (Course No. 1)**			
	I	Foundation of Ecology	4	**1**
	II	Ecosystem and Habitats		**1**
	III	Biogeochemical cycles		**1**
	IV	Natural Resources		**1**

SEMESTER III

Course outcomes

The students will be able to:

CO1: study the Ecosystem, its types and branches which can be applied for field study.

CO2: understand Habitats, Succession, its types and Application in the field study.

CO3: know Biogeochemical Cycles and application in environmental mitigation and pollution control.

CO4: comprehend Natural resources and their utilization, Bicitations and Gap Dynamics.

Course Code	**Topic: Environmental Botany and Recent Trends I**	**Credits: 4**
PSBO (EB)		
MODULE 1	**Foundation of Ecology** **Ecosystem:** Definition, Components of Ecosystems, Trophic Levels, Food Chains, Food Webs, Concept of Ecotone, Ecosystem Energetics, Laws of Thermodynamics, Energy Flow Models in Terrestrial Ecosystems Concept of Productivity, Principles of Limiting Factor, Liebigs Law, Shelford's Law of Tolerance, Basic Concepts in Ecology. **Branches of Ecology:** Autecology: Aims, Aspects: Definition and scope, Importance in ecology and conservation, Ecological factors- Abiotic and Biotic factors, Adaptations and physiological ecology, Life history strategies, Population dynamics; Habitat requirements and ecological niche; Community ecology; Applied autecology- Conservation biology, Invasive species ecology, Ecological restoration. Synecology: Plant Community, Ecological Amplitude, Population Characteristics: Association, Consociation Fasciation Society.	**1**
MODULE 2	**Ecosystem and Habitats** Succession; Causes, Types, Steps, Migration, Ecesis, Aggregation, Competition, Invasion, Hydrosere, Xerosere, Climax, Disclimax, Sub Climax	**1**

	Plant and Plant Community as Indicators: Forests as Indicators Grassland, Soil types, Salinity, Grazing, Indicators of Forests. Seaweeds: their uses maintenance and control Types of Habitat: Marine, Freshwater, Estuarine.	
MODULE 3	**Biogeochemical Cycles** **Gaseous Cycle**: • Nitrogen Cycle: Role of Nitrogen in Plant Metabolism and Biosphere. Nitrogen Cycle changes due to human activity – Agricultural Nitrogen Fixation, Industrial Emissions, Transportation. Impact in terms of Eutrophication of Environment and Health. • Water Cycle: Occurrence and role of water in Forest and Aquatic Ecosystems. • Carbon Cycle: Forms and places of occurrence of Carbon, Photosynthetic Sequestration of Carbon, Role of Carbon in Forest Ecosystems, Cycling of Carbon in Biosphere, Role of carbon in Global Warming Problem and its possible implications. **Sedimentary Cycle:** • Sulphur Cycle: Forms of Sulphur in biosphere and geosphere, in fossil fuels and its release with industrialization, Sulphur cycling in Soil Bacterial Metabolism. • o Phosphorus Cycle: Ecological Function, Biological Function and Process of the Cycle.	**1**
MODULE 4	**Natural Resources** Forest Resources: Use and Over-Exploitation, Biome- types in India, Biocitation of Tropical, Temperate, Alpine and Desert Biomes, Gap Dynamics in Tropical Forests and Parameters of Gap Dynamics, and Importance of gap dynamics.	**1**

Course Code PSBO (EB)	**Title of the Paper- Applied Environmental Botany and Contemporary Environmental Issues**			**Course No. II**
	1	Conservational Support	**4**	**1**
	2	Conservation & Remediation		**1**
	3	Introduction to Biodiversity		**1**
	4	Renewable and Non-Renewable Sources of Energy		**1**

Course outcomes: Students will be able to

CO1: understand the Role of National and International Organisations in Conservation and Environmental Issues.
CO2: learn about EIA (Environmental Impact Assessment), Watershed Management, and Soil Conservation.
CO3: comprehend the importance of Biodiversity and its conservation and Management.
CO4: differentiate Renewable and Non- renewable energy resources.

Course Code	**Title** Applied Environmental Botany and Contemporary Environmental Issues (**Course: II)**	**Credits**
PSBO (EB)		**4**
Module 1	**Conservational Support** **Role of National and International Organisations in Conservation and Environmental Issues** UNDP, WWF, World Bank, BNHS, MoEF, DST, DBT, CSIR, CPCB, Municipal Corporation Agenda 21, NGOS, IBGP, TRIPS. **Legislation Aiming at Conservation (Objectives and Penalties)** Environment Protection act 1986, Forest Conservation Act 1980, Wildlife protection Act 1972 **Conventions:** Earth summit, Vienna Convention, Ramsar Convention, Protocol: Montreal protocol, Cartagena protocol Case studies: Amazon Forest Fire, Bhopal Gas tragedy, Tuvalu -A sinking nation, Chernobyl disaster	**1**
Module 2:	**Conservation & Remediation** **EIA (Environmental Impact Assessment)** Types, Benefits, Process Monitoring and Evaluation, Risk Management. Role or Contribution of Botanist in EIA and EMP.	1

	Environmental Impact Assessment for Physical, Chemical, Biological and Socio-Economic Factors; Legislative Implications of EIA, Environmental Impacts Assessment and Environmental Auditing. **Watershed Management:** Economics Assessment of Watershed Development Vis-A-Vis Ecological and Environmental Protection. **Soil Conservation** - Definition, Causes for Erosion; Types - Wind and Water Erosion; Conservation and Management of Eroded Soils/Areas, Wind Breaks, Shelterbelts; Sand Dunes; Reclamation of Saline and Alkaline Soils, Water Logged and Other Waste Lands	
Module 3:	**Introduction to Biodiversity** **Biodiversity:** • Concepts and Levels, Species Concept, National & Global Status, Role of Biodiversity in Ecosystem Function and Stability, Speciation, and Extinction, Categories of RED Data (IUCN) -Distribution and Global Pattern • Biodiversity Hotspots, Inventory. Types of Resources., Conservation, PAN, In-Situ, Ex-Situ; Biosphere reserves, National Parks, Sanctuaries, Forest Conservation Chipko Movement. • Biodiversity Management Approaches: Measures of Maintaining Biodiversity, Need for Conservation of Biodiversity with Special Reference to Tropical Forest Biodiversity, Centers of Origin of Crops, Significance of Biodiversity; Plant Genetic Resources, Exploration and Collection; Crop Domestication, Plant Introductions; Migration and Utilization. • Endemism, Endemic and Exotic Ornamental Plants in India.	1
Module: 4	**Renewable and Non-Renewable Sources of Energy** • Concept and Demand of Energy, Growing Energy Needs, Renewable and Non-Renewable Sources, use of Alternate Energy Sources, Wind Energy, Solar Energy. Water as Source of Energy. • Biofuels Production, Use and Sustainability, Use and Over Exploitation of Energy Sources and Associated Problems. • Nuclear and geothermal energy Working of Instruments of Ecological Significance: 1. AAS (Atomic Absorption Spectrometry) 2. Garmin's Instrument- Global Positioning System (GPS) 3. Atomic Emission Spectrometer (AES), 4. Nitrogen analyzer	1

(Open Elective) **Course Code: PSBO (EB)** **Title: Waste Management** **Course V**		
Course Code: PSBO (EB)	**Title: Waste Management**	**Credit: 2**
Module I	**Introduction to Waste generation:** • Sources, generation, classification & composition of solid wastes. • Solid waste management methods- Sanitary land filling, Recycling, Composting, Vermicomposting, Incineration, energy recovery from organic waste	1
Module II	**Waste disposal and management techniques:** • Solid Waste Management Plan, • Waste minimization technologies, • Hazardous Waste Management, Sources & Classification, physicochemical properties., • Hazardous Waste Control & Treatment; Hazardous Waste Management & Handling rules, 1989 & 2000 (amendments), • Disaster Management, Fly ash generation & utilization, Primary, secondary, tertiary & advance treatment of various effluents.	1

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	SEMESTER III (Practical I)	**Credits 2**
PSBOP (EB)	**External**	
1	Determine Viability of Seeds Under Salinity Stress (TTC method)	
2	Determination of Total Organic Carbon of the given Soil sample	
3	Determine Simpson's Diversity Indices in Plant Community.	
4	Estimation Total Nitrogen from different Soil samples by Kjeldhal method.	
5	Estimation of Sulphur form the different Soil samples	
6	Estimation of Phosphorus from different Soil samples	
	Internal	
1	Study of Ecological Succession – Hydrosere, Xerosere, Climax,	
2	Study of Bicitations of Tropical Forests.	
3	Study of Gap Dynamics of Local Forest.	
4	Prepare a report of anyone of the following Habitat – Marine Freshwater, Estuarine.	

	SEMESTER III (Practical II)	
	External	
PSBOP (EB)		**Credits 2**
1	Study of Vegetation Community and Identification of Indicator Species.	
2	Comparison of Primary Productivity by I) Chlorophyll Method, II) Harvest Method And III) Light And Dark Bottle Method in Polluted and Unpolluted Regions.	
3	Study the Quantitative Characters of Plant Community by Quadrat Method. (Density, Frequency and Abundance)	
4	Determination of pH, Electrical Conductivity, and Water Holding Capacity of Different Types of Soil.	
	Internal	
1	Study of Principle, Working, Application of Instruments of Ecological Significance • AAS (Atomic Absorption Spectrometry) • Garmin's Instrument- Global Positioning System (GPS) • Atomic Emission Spectrometer (AES), • Nitrogen analyser,	
2	Study of Forest Over Exploitation – Local Case Study	
3	Study of different types of forest in Maharashtra.	
4	Preparation of Biofuel using waste products	
5	EIA Report Preparation-(Field Exercise-Report To Be Submitted along with Journal).	
6	Preparation of Patent File – Any One product with Innovative methods	

	SEMESTER III Elective (Practical) Waste Management	
PSBO (EB)	**External**	**Credits 2**
1	Composting methods – Pit/Vermicompost.	
2	Collection and classification of Solid waste	
3	Biodegradation of textile dyes using microorganisms	
4	Phytoremediation of textile dyes using suitable plant	
5	Estimation of organic carbon in compost.	
	Internal	
1	Physico-chemical analysis and characterization of solid waste	
2	Process of biogas production (NISARGARUNA biogas plant)	
3	Identification of plants used for phytoremediation	
4	Design aspects of incinerators, Sanitary landfill site, Biogas plant.	
5	Waste generation pattern – questionnaire and survey.	

Sem. - IV

M.Sc. (Botany)
Angiosperms and Phytochemistry (ANP)
(Sem- IV)

Course Code PSBO (ANP)	**Title of the Paper- Trends in Angiosperm Taxonomy Course No. 1**			
	1	**Plant-Animal Interaction**	4	**1**
	2	**Biodiversity conservation**		**1**
	3	**Evolution and Speciation**		**1**
	4	**Taxonomy and Local Administration; Data Analysis and Scientific Communication**		**1**

Course Outcomes:

Upon successful completion of this course, the student will be able to:

CO1: Understand the intricate interactions between plants and their pollinators, including the structural and functional adaptations of flowers. They will be equipped with the knowledge and skills necessary to conduct research on plant-animal interactions and contribute to the conservation of these vital ecological relationships.

CO2: Evaluate various conservation strategies, such as in situ and ex situ conservation, habitat restoration, protected areas, and community-based conservation.

CO3: Discuss the implications of speciation and evolutionary studies for biodiversity conservation and management.

CO4: Apply theoretical knowledge to real-world urban biodiversity management scenarios

Course Code	Title	Credits

PSBO (ANP)	**Trends in Angiosperm Taxonomy**	**4**
Module 1	**Plant-Animal Interaction:** • **Floral phyllotaxies** (Arrangement pattern of the structural Modules); • **Floral constructio**n (Allometry, stacking and stuffing, open and closed flower, flag flower, lip flower, trap flower monosymmetric and poly symmetric flowers); • **Floral adaptation to different pollinators;** • **Flower longevity**	**1**
Module 2:	**Biodiversity conservation:** • **Biodiversity** – Concept, Levels, Significance of biological diversity; Keystone species, Flagship species, indicator species and their role in maintenance of Diversity. Loss of biological diversity. • **IUCN Categorization; Assessment techniqu**es for Red Listing; **Submission process** in Red List database; Conservation planning • **Conservation strategies**	**1**
Module: 3	**Evolution & Speciation** • Evolution - Evolutionary characters: Primitive vs Advanced characters; Homology & Analogy; Parallelism and Convergence • Concept of Intra population variation, Cryptic species • Species concept – Biological and Taxonomic • Speciation - Definition and types: Sympatric, Allopatric, Peripatetic, and Parapatric speciation; hybrid, Apomictic speciation with emphasis on examples from India, possibly Maharashtra; • Endemism, Keystone species, Flagship species with reference to Maharashtra	1
Module: 4	**Taxonomy and Local Administration:** • **Tree Authority -** Its structure and role in maintaining urban biodiversity; • **Tree Census**, Methods involved in Tree Census, and its significance **Data Analysis and Scientific Communication** • **Statistical tools in taxonomy** • **Scientific Communication:** Different modes of communication, Steps involved in proposal writing, Scientific paper writing; Ethics in scientific writing; Popular and Scientific talks	

Course Code PSBO(ANP)	Title of the Paper- Trends in Phytochemistry		Course No. 2	
	1	**Indian Traditional Knowledge**	4	**1**
	2	**Biological methods in Evaluating crude drugs**		**1**
	3	**Study of Medicinal plants I**		**1**
	4	**Study of Medicinal Plants II**		**1**

Course outcomes:

On completion of the course students will be able to

CO1: understand the Indian Traditional Knowledge, its relevance in today's world, and its applications in sustainable development. They will be equipped with the knowledge to appreciate and utilize ITK in various professional and academic pursuits.

CO2: adept at using biological methods to evaluate the hepatoprotective, anti-fertility, anti-inflammatory, and anti-microbial properties of crude drugs. They will have a solid foundation in both theoretical knowledge and practical skills, enabling them to contribute to research and development in pharmacology and related fields.

CO3: possess the knowledge and skills to evaluate the pharmacological properties, cultural significance, and ethical considerations of these plants, preparing them for further research or professional practice in the field of medicinal botany and pharmacognosy.

Course Code	Title	Credits
PSBO (ANP)	**Trends in Phytochemistry**	**4**
MODULE 1	**Indian Traditional Knowledge** – • Concept, Importance in the present scenario • TKDL - Traditional Knowledge Digital Library **Taxonomy in Sustainable Development:** • Knowledge of Plants in the textile industry concerning choice of fiber, and Botanical motifs. • History of Traditional textile forms vis a vis botanical knowledge - A case study on Paithani/ Maheshwari / Patola or any other form • Plant-based paintings, Botanical Artifacts - A means of sustainable economy	1
MODULE 2	**Biological methods in Evaluating crude drugs** • Hepatoprotective • Anti-fertility • Anti-inflammatory • Anti-microbial	1
MODULE 3	**Study of Medicinal Plants I** Study of medicinal plants (Two from each): • Psychoactive, • Fumitories & Masticaries; • Stimulants • Adulterant, Substitute & Controversial Drug (One each)	1
MODULE 4	**Study of Medicinal Plants II** Study of medicinal plants (Two from each): • Nervine • Antidiabetic • Anticancerous • Immunity boosters • Plants in Joint ailments	1

Course outcomes:

Students will be able to

CO1: identify and describe the morphological and ecological adaptations of flowers pollinated by insects, providing examples.

CO2: differentiate between psychoactive drugs, fumitories, masticaries, and stimulants based on their phytochemical profiles.

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Course Code	Title	Credits
PSBOP (ANP)	**Practicals based on Course I**	**2**
External: 1. Write a morphological description of any one plants belonging to ▪ Tubular flower ▪ Open flower ▪ Flag flower 2. Study of adaptations in :(Any one examples of each) ▪ Entomophilous flower ▪ Anemophilous flower ▪ Hydrophilous flower 3. Prepare Red list (global) assessment report of any one species selected from Red List Database. Use at least 3 points of your own in the analysis. Use iNaturalist & GBIF for compilation of the location data for the assessment in addition to your own data. 4. Perform ANOVA, paired and unpaired T-tests using data analysis tool from Excel (Use the data obtained from Practical 1) **Internal:** 1. Write a status review report in rocky plateau/ forest/ mangrove forest 2. Case study on pollination biology study of any of the herbaceous species/ Arboreal species from the surrounding area 3. Write a review using scientific papers from UGC-listed journal/s, check for plagiarism using any available software, and submit. 4. Case study on any one of the types of speciation 5. Prepare a plant/ tree census report of your campus or adjoining areas. 6. Prepare a PBR (People's Biodiversity Register)		1

Course Code	Title	Credits
PSBOP (ANP)	**Practicals based on Course II**	**2**
Course II **External:** 1. Identification of Psychoactive drugs using phytochemical tests. (Preliminary screening/TLC) 2. Identification of Fumitories using phytochemical tests. (Preliminary screening/TLC) 3. Identification of Masticaries using phytochemical tests. (Preliminary screening/TLC) 4. Identification of Stimulants using phytochemical tests. (Preliminary screening/TLC) 5. Identifying Adulteration in the given herbal sample using Macroscopic/Microscopic/ Physicochemical analysis. 6. Identifying Substitution in the given herbal sample using Macroscopic /Microscopic/ Physicochemical analysis. **Internal:** 1. Determination of Minimum Inhibitory Concentration (MIC) of the given herbal extract. 2. Study of antimicrobial activity by the disc diffusion method/agar cup method 3. Identify the authentic drug from the controversial drugs (Based on Vernacular names/Trade names) 4. Study the impact of storage conditions, Harvesting methods, collection time, Season, age and stage of the plant, and geographical regions of any one plant-based drug available in Maharashtra. 5. File a patent for an herbal drug or medicine that is found to possess new indications such as novel therapeutic activity in its extract form or formulation preparation. 6. Prepare a unique recipe for a diabetic/ heart/ thyroid patient using basic fruits/vegetables available in the local market. Write the scientific approach that is followed to prepare the recipe. Justify the quality of the product to a consumer.		1

Course outcomes:

At the end of the course the students will be able to:

CO1: Comprehend the nutraceutical value of food and human nutrition.

CO2: Understand the concept of food technology and processing.

CO3: Gain knowledge of food adulterants and their types.

(Open Elective)		Credits
PSBOA	**Course Title: Biodiversity and Ecotextile**	**2**
Module 1 – Tree Census and Scientific communication		**1**
	Tree Authority – • Its structure and role in maintaining urban biodiversity; • Methods involved in **Tree Census** and its significance	
	Biodiversity: • Types of biodiversity, reasons for biodiversity loss, methods of biodiversity conservation; • **IUCN Categorization; Assessment techniques** for Red Listing; • **Submission process** in Red List database; • **Conservation planning**	
	Scientific Communication: • Different modes of communication, • Steps involved in proposal writing, • Scientific paper writing; • Ethics in scientific writing; • Popular and Scientific talks • **Use of Excel** in plant taxonomy study	
Module 2 – Ecotextile		**1**
	• **Indian Traditional Knowledge** – Introduction to organic fibers, and dyes, importance in present Indian and Global scenario. • **Plants in textile industry** with reference to choice of fiber, dye and Botanical motifs. • **Role of literature and ethnobotanical data** in search of new fibers/ dyes/botanical designs. • **History of Traditional textile forms vis a vis botanical knowledge** - A case study on Paithani/ Maheshwari / Patola or any one form – Practical and Theoretical aspects • **Plant based paintings, Botanical Artifacts** - A means of sustainable economy.	

Course outcomes:

At the end of the course the students will be able to,

CO1: Learn to compile and present findings from plant taxonomy studies using Excel.

CO2: Engage in hands-on activities related to the selected textile form, including the use of traditional methods and materials.

CO3: Develop skills in utilizing ethnobotanical information for innovative applications in medicine, textiles, and dyeing.

(Elective) Practicals		Credits
Course V	**Course Code: PSBO**B	**2**
External		**1**
1.	Prepare Red list (global) assessment report of any one species selected from Red List Database. Use at least 3 points of your own in the analysis. Use iNaturalist & GBIF for compilation of the location data for the assessment in addition to your own data.	
2.	Extract natural dyes from *Clitoria/ Lawsonia/Beta/Curcuma* and apply them to textiles.	
3.	Study of Absorption spectrum and Absorption maxima for the extracted dyes. (*Clitoria/ Lawsonia/Beta/Curcuma*)	
4.	Identify and test the properties of different plant-based fibers used in textiles.	
5.	Perform ANOVA, paired and unpaired T-tests using data analysis tool from Excel (taxonomic data from PBR)	
Internal		**1**
1.	Prepare a plant/ tree census report of your campus or adjoining areas.	
2.	Prepare a PBR (People's Biodiversity Register)	
3.	Develop a scientific research proposal on a chosen topic related to biodiversity or urban ecology.	
4.	Create textile designs using botanical motifs.	
5.	Ethnobotanical survey with reference to fibre, dyes and plant-based designs	
6.	Create artworks using plant-based pigments and natural materials.	

Note:

- A minimum of **Two** field excursions (with at least one beyond the limits of Mumbai / Local Area) for habitat studies are compulsory.
- Field work of not less than **eight hours** duration is equivalent to one period per week.
- Industrial visit / Institutional visit at least **One** per Semester are compulsory.

References Books

1. Kore G.B. Statistical data analysis using MS-Excel, Nirali Publication 2019
2. Kocchar S. L. Economic Botany, Cambridge University press, 2016
3. Hill A., Economic Botany, A textbook of Useful Plants and Plant Products, McGraw Hill Book Company 1937
4. Guidelines for Application of IUCN red list criteria at regional levels Version 3.0, International Union for conservation of Nature and Natural resources, Prepared by the IUCN Species survival Commission 2003

Ecology and Environmental Botany (Specialization 2)

Exit option: PG Diploma (44 Credits) after Three Year UG Degree									
II	**6.5**	**Sem III**	Course 1 **Environmental Botany and Recent Trends I** Credits 4 Course 2 **Applied Environmental Botany and Contemporary Environmental Issues** Credits 4 Course 3 **Practicals based on Course I & II** Credits 4 (2+2) Course 4 **IPR and Entrepreneurship skills** Credits 2	**Credits 4 (2+2)** Course 1 **Waste Management** OR Course 2 **From other Specialization**			4	22	**PG Degree After 3- Yr UG**
		Sem IV	Course 1 **Environmental Botany and Recent Trends II** Credits 4 Course 2 **Applied Environmental Botany and Contemporary Environmental Issues II** Credits 4 Course 3 **Practicals based on Course I & II** Credits 4 (2+2)	**Credits 4** **Environmental Biotechnology** OR Course 2 **From other Specialization**			6	22	
Cum. Cr. for 1 Yr PG Degree			**26**	**8**			**10**	**44**	
Cum. Cr. for 2 Yr PG Degree			**54**	**16**	**4**	**4**	**10**	**88**	

SEMESTER IV

Course Code PSBO (EB)	**Title of the Paper- Environmental Botany and Recent Trends II Course No. 1**			
	1	**Environmental Pollution and its impact**	4	**1**
	2	**Climatic Change and its mitigation**		**1**
	3	**Plant Population Dynamics and Stress Ecology**		**1**
	4	**Management of Indian Coastal Zones**		**1**

Course Code	**Title**	**Credits**
PSBO (EB)	**Environmental Botany and Recent Trends II**	**4**
Module 1: Environmental Pollution and its impact ● Photochemical smog-Concept, Types of smog, inhibition, adverse effect of photochemical smog. Types of particulate matter, removal of particulate matter from air. ● Radiation- Manmade and natural, biological effects of radiation. Range of permissible doses. Abnormal exposures in emergencies and accidents. Nuclear fission and radiation hazards Radioactive waste management. ● Fossil fuels - automobile emissions, Alternate fuels-CNG, Propane and methanol. ● Environmental impact of petroleum products- Impact of crude oil on marine life.		**1**
Module 2: Climatic Change and its mitigation ● Global Climate Change: Concept, Green House Gases, Their Major Sources, Ozone Layer ● Consequences of Climate Change (CO2 Level, Global Warming, UV Radiation). ● Concept Of Carbon Footprint, Carbon Credits, Importance of Carbon Foot Printing. ● International efforts for mitigating climate change- Suitable case studies.		**1**
Module 3: Plant Population Dynamics and Stress Ecology ● Population - Characteristics and Measurement; Community - Habitats, Niches, Population Dynamics, Species and Individual in the Ecosystem. ● Allelopathy: Concept, Allelochemicals, Leachates, Root Exudates, weed –Crop Interactions, Weed Control, Herbicides from Natural Compounds, Methods for Determining Allopathy, Allelochemicals as Nematicides. ● Stress Ecology: Stress and plant life stress due to temperature, radiation, water, salt and anthropogenic activity. ● Bioindicators of environmental pollution.		1

Module 4: Management of Indian Coastal Zone ● Coastal Zone Management- Coastal Environment, Coastal Issues, Land Use and Changes. ● Coastal Zone Management, Major initiatives, Prohibited and Regulated activities in Coastal Areas, State Coastal Zone Management Authorities. ● Mangrove: Habitat and Characteristics, Plantation- Establishment and Rehabilitation of degraded mangrove habitats; silvicultural systems. ● Role of mangroves in the protection of habitats against natural disasters.	1

Course Outcomes:

Upon successful completion of this course, the student will be able to:

CO1: Analyze different pollutants as well as provide suitable remediation measures

CO2: Understand the climate changes and provide solutions for its mitigation

CO3: Recognise the various factors of Population and community and get to know the stress ecology.

Course Code PSBO (EB)	Title of the Paper- Applied Environmental Botany and Contemporary Environmental Issues II Course No. 2			
	1	Restoration of Ecosystems I		1
	2	Restoration of Ecosystems II		1
	3	Restoration of Land		1
	4	Watershed management		1

Course outcomes:

On completion of the course students will be able to

CO1: Understand the restoration process and provide suitable solutions

CO2: Use different instruments of ecological significance to provide better remediation.

Course Code	Title: Applied Environmental Botany and Contemporary Environmental Issues II	Credits
PSBO (EB)		4
MODULE 1: Restoration of Ecosystems I ● Urban Forests. Role of Urban Forests. Study of Urban Health Through Surveys of Urban Trees ● Holistic approach to study- Industrial Areas, Population and their Habitats, water and Waste Disposal. ● Transportation, Infrastructure, Education, Health, Sport and Entertainment. Amenities and Cultural Issues- and Relationship of all these with Plants. ● Urban Issues: Urban Challenges, Urban Transport System, Energy Demand ● Case Study: Mumbai and Kolkata, with reference to ○ Air Pollution, Noise Pollution, Water Pollution. ○ Restoration efforts Gardens, design of Waste Management, waste storage Transportation, reclamation. ○ Urban forestry and ecotourism		1
MODULE 2: Restoration of Ecosystems II ● Restoration of Mangrove Ecosystem- Mangroves of coastal Maharashtra, Selection and Treatment of Coastal Area with Reference to Tidal Situation and Physical Properties. ● Restoration of Mangroves: Choice of Species, Collection of Seeds and Seedling Material, Storage and Plantation. ● Problems of Seed Dormancy, Tidal Forces, Predation Nutrient Supply and Restoration Methods. ● Disaster management: Natural calamities and their impact, PEER –Program for enhancement of Emergency response and LCA –Life cycle assessment.		1

MODULE 3: Restoration of Land and instrumentation ● Solid waste management: Classification of waste, waste generation, separation and processing, waste treatment and disposal, Factors governing the choice of technology ● Municipal solid waste management and Handling Rules 2013, Responsibilities of Municipal authorities, state and Central Control Boards, Management of municipal solid waste (MSW act 2013). ● Biological treatment of wastewater from the food processing Industry ● Biopesticides and integrated pest management ● Microbial transformation of heavy metals ● **Instruments used for pesticide detection and waste analysis**: Gas Chromatography, Biosensors for pesticide detection: electrochemical based, immune based, optical, and enzyme-based biosensors, Biodigester.	1
MODULE4: Watershed management ● Concepts of watershed; the role of mini-forests and forest trees in overall resource management, forest hydrology. ● Watershed development concerning torrent control, river channel stabilization, avalanche, and landslide controls, and rehabilitation of degraded areas; hilly and mountain areas. ● Watershed management and environmental functions of forests. ● Water-harvesting and conservation; groundwater recharge and watershed management; the role of integrating forest trees, horticultural crops, field crops, grass, and fodders.	1
Course outcomes: At the end of the course the students will be able to, **CO1:** Understand the concept of Bioremediation. and suggest different remediation techniques **CO2:** Comprehend the importance of hazardous waste disposal **CO3:** Critically analyze the waste management. **CO4:** Gain knowledge on different types of biofuels and bioenergy.	

Open Elective	Credits
Course V **Course Code: PSBO (EB)** **Title: Environmental Biotechnology**	**2**
MODULE 1: Bioremediation	**1**
• Introduction, constraints and priorities of Bioremediation, Biostimulation of Naturally occurring microbial activities, Bioaugmentation, in situ, ex situ, intrinsic & engineered bioremediation	
• Solid phase bioremediation - land farming, prepared beds, soil piles, Phytoremediation. Composting, Bioventing & Biosparging; • Liquid phase bioremediation - suspended bioreactors, fixed biofilm reactors.	
• Hazardous Waste Management biotechnology application to hazardous waste management - examples of biotechnological applications to hazardous waste management – cyanide detoxification - detoxification of oxalate, urea etc. - toxic organics -phenols	
• Concept of bioremediation (in-situ & ex-situ), Bioremediation of toxic metal ions biosorption and bioaccumulation principles. Concepts of phytoremediation. Microbial leaching of ore-direct and indirect mechanisms. Mining and metal. Use of microorganisms in augmentation of petroleum recovery. Biotechnology-with special reference to Copper and Iron	
MODULE 2: Bioenergy and Biofuels	**1**
• Introduction to Bioenergy and Biofuels- Definition and importance, Historical perspective and development • Types of Biofuels- First-generation biofuels: bioethanol, biodiesel; Second-generation biofuels: cellulosic ethanol, biomass-to-liquid (BTL) fuels' Third-generation biofuels: algal biofuels; Advanced biofuels: biogas, biohydrogen	
• Production Technologies- o Bioethanol production: fermentation of sugars and starches, o Biodiesel production: transesterification of vegetable oils and animal fats, o Biogas production: anaerobic digestion of organic waste, Algal biofuel production: cultivation and processing of microalgae	
• Environmental and Economic Impacts- o Life cycle analysis of biofuels, Greenhouse gas emissions and carbon footprint, o Economic feasibility and market potential	
• Advances and Innovations in Bioenergy- o Genetic engineering for enhanced biofuel production, o Integration of bioenergy with other renewable energy systems, o Policy and regulatory frameworks supporting bioenergy	

	SEMESTER IV (Practical I) Based on Course 1	
PSBOP (EB)	**External**	**Credits 2**
1	Comparative study of Foliar Dust Capturing Capacity from Different Plant Species (minimum five) collected from polluted and unpolluted sites.	
2	Determination of Water, Ascorbic Acid content, and pH of Leaf collected from polluted and unpolluted sites	
3	Comparative study of Biological Oxygen Demand Value for Industrial Waste effluent collected from any two sites.	
4	Identification of Mangroves	
	Internal	**Credits 2**
1	Measurement of sound using a decibel meter in different areas, at different times.	
2	Comparative study of Chemical Oxygen Demand Value For Industrial Waste effluent collected from any two sites.	
3	Comparative Study of Water Turbidity of Sea Water, Pond Water, Polluted Water	
4	Study of mangrove: Field report	
5	Working and applications of instruments: Gas Chromatography, Biosensors for pesticide detection: electrochemical based, immune based, optical, and enzyme-based biosensors, Biodigester.	

	SEMESTER IV (Practical II) Based on Course 2	
PSBOP	**External**	**Credits 2**
1	Comparison of contaminated and not contaminated water bodies using physio-chemical parameters such as pH, Turbidity, Chloride, nitrate content.	
2	Vegetation mapping using suitable method/instrument. (Garmin etc.)	
3	Study of biodiversity on different locations with the help of Shannon's diversity index	
4	Effect of vegetation cover (sand dune plants) in prevention of soil erosion	
5	Desalination of saline soil using plants	
PSBOP	**Internal**	**Credits 2**
1	Principle and working of biodigester	
2	Allelopathic effect of weed extracts on seed germination	
3	Preparation of artificial key of mangrove plants	
4	Report writing on- Role of Vegetation in Watershed Management	

	SEMESTER IV Open Elective (Practical) Environmental Biotechnology	
PSBOP (EB)	**External**	**Credits 2**
1	Isolation of biodegrading Microorganisms from contaminated soil using serial dilution method	
2	Assessment of heavy metal tolerance in bacterial and fungi	
3	Biodegradation of textile dyes using microorganisms	
4	Phytoremediation of textile dyes using suitable plant	
5	Bioethanol production from lignocellulosic biomass	
6	Types of biofuels	
	Internal Practicals	
1	Assessment of ability of *Brassica* sp for Phytoremediation of heavy metal contaminated soil	
2	Production of biodiesel from vegetable oil through the process of transesterification	
3	Process of biogas production (NISARGARUNA biogas plant)	
4	Identification of plants used for phytoremediation	

Note:

- A minimum of **Two** field excursions (with at least one beyond the limits of Mumbai / Local Area) for habitat studies are compulsory.
- Field work of not less than **eight hours** duration is equivalent to one period per week.
- Industrial visit / Institutional visit at least **One** per Semester are compulsory.

References Books

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4. Moduleed States Government Accountability Office (2008) Natural Resource Management. Nova Science Publishers Inc, 10th Edition.
5. Stacy Keach (2016) Natural Resources Management. Syrawood Publishing House.
6. Rathor, V.S. and Rathor B. S. (2013) Management of Natural Resource for Sustainable Development. Daya Publishing House, New Delhi.
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9. Andrew Davis • Garrett Nagle, Environmental Systems and Societes, 2nd Edition, Pearson Baccularate, published by Pearson Education Limited, 80 Strand, London, WC2R 0RL.
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11. Ambasht and Ambasht, A textbook of Plant Ecology, 15th Edition 2008, CBS publishers and Distributors
12. Daubenmire R.F. Plants and Environment- A Text Book of Plant Ecology (3rd edition). John Wiley & Sons. New York, 1974.
13. Kendeigh S.C. Ecology with Special Reference to Animals and Man. Prentice Hall of India Pvt. Ltd., New Delhi,1980.
14. Kumar H.D. Modern Concepts of Ecology (3rd edition). Vikas Publishing House Pvt., Ltd. Delhi,1996.
15. Kumar H.D. General Ecology. Vikas Publishing Pvt. Ltd., Delhi, 1997.
16. Kermondy F.J. 1996. Concepts of Ecology.Prentice Hall of India Pvt.Ltd.,New Delhi.
17. Layzell D. B., Turpin D. H., Dennis D. T. & LeFebvre D. D. Plant Metabolism, Prentice Hall PTR, 1997.
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19. Weaver J.E.& Clements. S.E. 1966. Plant Ecology. Tata McGraw Publishing Co. Ltd. Bombay.
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MYCOLOGY AND PLANT PATHOLOGY (Specialization 3)

Exit option: PG Diploma (44 Credits) after Three Year UG Degree									
II	**6.5**	**Sem III**	Course 1 **General Mycology & Techniques** Credits 4 Course 2 **Plant Pathology and Medical Mycology** Credits 4 Course 3 **Practicals based on Course I & II** Credits 4 (2+2) Course 4 **IPR and Entrepreneurship skills** Credits 2	**Credits 4 (2+2)** Course 1 **Agro-Industrial Mycotechnology** OR Course 2 **From other Specialization** OR			4	22	**PG Degree After 3- Yr UG**
		Sem IV	Course 1 **General Mycology & Techniques** Credits 4 Course 2 **Plant Pathology and Biotechnology** Credits 4 Course 3 **Practicals based on Course I & II** Credits 4 (2+2)	**Credits 4** Course 1 **Industrial Mycology** OR Course 2 **From other Specialization** OR			6	22	
Cum. Cr. for 1 Yr PG Degree			**26**	**8**			**10**	**44**	
Cum. Cr. for 2 Yr PG Degree			**54**	**16**	**4**	**4**	**10**	**88**	

COURSE OUTCOMES

COURSE CODE	TITLE AND LEARNING OUTCOMES
	SEMESTER III
PSBO (MPP)	**General Mycology & Techniques:** Students will be able to – 1. Understand the significance of fungi in various ecological processes. 2. Describe the general characteristics of major fungal phyla, including thallus structure, reproduction, and key life cycle features. 3. Compare and contrast the traditional classification system of fungi with the recent phylogenetic classification. 4. Explain the different modes of nutrition exhibited by fungi and discuss the nutritional requirements of fungi. 5. Demonstrate proficiency in various mycological techniques and perform sample preparation techniques for microscopic study.
PSBO (MPP)	**Plant Pathology and Medical Mycology:** Students will be able to – 1. Understand the importance, historical development, and objectives of plant pathology, including the distinction between biotic and abiotic causes of plant diseases. 2. Describe the host-parasite interaction and the processes involved in disease recognition, infection, and symptom development in plants. 3. Explain the role of environmental factors and host nutrition in disease development, including the induction of disease defense strategies. 4. Identify the causal organisms, symptoms, disease cycles, and control measures for specific diseases affecting field crops. 6. Discuss the role of aero-mycoflora and fungal allergies in human health and evaluate the mechanisms of antifungal agents commonly used in medical practice. 7. Identify common foodborne fungi and understanding their impact on food safety and quality. 8. Understand the historical background, detection methods, health effects, and regulatory aspects of mycotoxins in food and recognize the toxic compounds associated with mushroom poisoning.
	SEMESTER IV
PSBO (MPP)	**General Mycology & Techniques:** Students will be able to – 1. Understand the rules of nomenclature in fungal taxonomy, including the principles outlined in the code of Botanical nomenclature. 2. Describe the systematic position and life cycle of representative genera from major fungal classes. 3. Explain the morphology, anatomy, reproduction, ecological aspects, and economic importance of lichens.

	4. Explore fungal genetics and discuss the role of Yeast Artificial Chromosomes (YACs) in genetic engineering and their applications in fungal research. 5. Identify and describe extremophilic fungi and their adaptations to extreme environments. 6. Recognize the scope and importance of fungi in industrial mycology and their applications in various industries. 7. Describe the principles and types of fermentation used in industrial mycology. Characterize the cultural and morphological characteristics of fungi and apply molecular and biochemical techniques in fungal studies, utilize molecular approaches for fungal taxonomy, and employ bioinformatic tools for data interpretation.
PSBO (MPP)	**Plant Pathology and Biotechnology:** Students will be able to – 1. Identify the causal organisms, symptoms, disease cycles, and control measures for specific fungal, bacterial, and viral diseases affecting crop plants. 2. Understand the physiological disorders in plants caused by temperature, soil moisture, and nutritional imbalances, and implement management strategies to mitigate their effects. 3. Explain the economic significance of seed-borne diseases and their impact on seed quality and crop production and evaluate management strategies for seed-borne diseases. 4. Analyze the effects of pathogens on plant physiological functions, including photosynthesis, respiration, and water translocation, and understand how these processes are disrupted during disease development. 5. Describe the genetics of plant disease resistance and the molecular mechanisms underlying plant-pathogen interactions. 6. Understand the concept of mycoremediation, production of biofuels, production of pharmaceutical products using fungal biotechnology.

SEMESTER III

Course Code PSBO (MPP)	**Title of the Paper- General Mycology & Techniques Course No. 1**			
	1	**Diversity and Distribution of fungi**	4	**1**
	2	**Fungal Systematic and Life history**		**1**
	3	**Fungal Physiology**		**1**
	4	**Myco-techniques**		**1**

Course outcomes

The students will be able to:

CO1: Understand the significance of fungi in various ecological processes., describe the general characteristics of fungi from various groups and evaluate the nature and distribution of fungi in different habitats

CO2: Describe the general characteristics of major fungal phyla, including thallus structure, reproduction, and key life cycle features, Compare and contrast the traditional classification system of fungi with the recent phylogenetic classification.

CO3: Illustrate the diversity of fungal interactions with other organisms with examples, Analyze the modes of nutrition in fungi, and the impact of various nutrients on their physiological processes.

CO4: Demonstrate proficiency in various mycological techniques and perform sample preparation techniques for microscopic study apply various screening methods for cellulolytic fungi.

Course Code	Topic	Credits: 4
PSBO (MPP)	**General Mycology & Techniques**	
MODULE 1	**DIVERSITY AND DISTRIBUTION OF FUNGI** ➢ Introduction to fungi and their significance. ➢ General characteristics of fungi (Myxomycotina, Mastigomycotina, Oomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina) - Thallus structure, Reproduction, Heterothallism, Heterokaryosis and Parasexual cycle in fungi. ➢ Fungal ecology and diversity- Soil fungi, Water fungi and Endophytes.	**1**
MODULE 2	**FUNGAL SYSTEMATIC AND LIFE HISTORY** ➢ Fungal Taxonomy- A comparative account of classification of fungi proposed by Alexopoulos and Mims (Upto the order) with recent Phylogenetic classification (Up to class). ➢ Morphological characters and conidial ontogeny. ➢ Systematic position and Life cycle of the following classes of fungi with emphasis on the given genera: Myxomycotina: *Physarum*, Mastigomycotina: *Achlya*, Oomycotina: *Pythium*,Zygomycotina: *Pilobolus* (as per Alexopoulos and Mims Classification)	**1**
MODULE 3	**FUNGAL PHYSIOLOGY** ➢ Mode of nutrition-Saprophytic, Parasitic, Mutualistic, Hyperparasitic, Predaceous. ➢ Nutrition in fungi with reference to: i) Carbon ii) Sulphur iii) Potassium iv) Magnesium v) Nicotinic acid vi) Riboflavin, vi) Nitrogen, vii) Phosphorus, viii) Thiamine ix) Folic acid x) Pantothenic acid xi) Iron ➢ Mevalonate pathway, Shikimic acid pathway	**1**
MODULE 4	**MYCO-TECHNIQUES** ➢ Collection, examination (field characters), sterilization, isolation, purifications, sporulation, maintenance, and preservation. ➢ Selective isolation and screening methods - cellulose degrading fungi, qualitative and quantitative screening for enzymes. ➢ Preparation of samples for microscopic study - Slide culture, Slide preparation, staining of micro and macro fungi ➢ LAF and Bio-safety measures	**1**

	Title of the Paper- Plant Pathology and Medical Mycology

Course Code PSBO (MPP)	Course No. II			
	1	Principles of plant pathology	**4**	**1**
	2	Diseases of field crops and control measures		**1**
	3	Medical mycology		**1**
	4	Fungal contaminants in food		**1**

Course outcomes

On completion of the course, Students will be able to:

CO1: Understand the importance, historical development, and objectives of plant pathology.

CO2: Identify the causal organisms, symptoms, disease cycles, and recommend control measures for specific diseases affecting field crops.

CO3: Describe the principles and practices of medical mycology, focusing on the diagnosis, treatment, and prevention of fungal diseases in humans and animals.

CO4: Identify common foodborne fungi and understanding their impact on food Safety and quality.

Course Code	Title	Credits
PSBO (MPP)	**Plant Pathology and Medical Mycology**	**4**
Module 1	**PRINCIPLES OF PLANT PATHOLOGY** ➢ Importance, history and objective of plant pathology, definition and concept of plant diseases, biotic and abiotic causes of plant diseases. ➢ Host parasite interaction, recognition concept and infection, disease development and general symptoms, Role of environment and host nutrition in disease development ➢ Disease defense strategies- Oxidative burst, Phenolics, Phytoalexins, PR proteins and Elicitors	**1**
Module 2	**DISEASES OF FIELD CROPS AND CONTROL MEASURES** ➢ Causal organism, Symptoms, Disease Cycle and Control measures- • Fungal Disease: Downy Mildew of Grapes, Loose smut of wheat • Bacterial disease: Leaf blight of Rice • Viral disease: Banana bunchy top virus • Mycoplasmal disease: Little Leaf of Brinjal Control Measures: Physical, Chemical and Biological	1
Module 3	**FUNGAL CONTAMINANTS IN FOOD** ➢ Food borne fungi: Common contaminants of i) Fresh food, ii) Processed food iii) Stored food ➢ Use of chemical preservatives to protect the food against contamination: ➢ Mycotoxins- historical background, detection, estimation, effect on human /animal health. Mycotoxins and their types i) Alternaria Toxins ii) Citrinin iii) Ochratoxins iv) Patolin v) Penicillic Acid vii) Sterigmatocystin viii) Zearalenone. Mushroom poisoning- Amanitin, Muscarine, Psilocybin	1
Module 4	**MEDICAL MYCOLOGY** ➢ Principles and Practice of Medical Mycology ➢ Fungal diseases in human and animals- Candidiasis: dermatophytes, Aspergillosis: systemic and opportunistic fungal pathogens, Saprolegniosis: water mold ➢ Aero-mycoflora and fungal allergies Antifungal agents- Nystatin, Griseofulvin, Azoles	1

M.SC PART II SEMESTER III
(ELECTIVE)

Course Code PSBO (MPP)	**Title of the Paper- Agro-Industrial Mycotechnology** **Course No. Elective**			
	I	**Fungi in Agriculture**		**1**
	2	**Fungi in bioremediation & Value added products**		**1**

Course Outcomes

On completion of the course student will be able to:

CO1: Identify different types of mycorrhizal associations.
Evaluate the economic feasibility and practical considerations of incorporating mycorrhizal biofertilizers into agricultural systems,
Understand the process of Composting and significance of microbial consortia, Design integrated composting systems, using organic waste materials and microbial inoculants, optimizing the composting process for efficient decomposition and nutrient recycling.

CO2: Define mycoremediation and lignolytic fungi, explaining their roles in environmental cleanup and degradation of lignin-based pollutants.
Identify diverse value-added products obtained from Ganoderma and mushroom species, apply various cultivation methods and techniques to grow different species of mushrooms

(Elective) **Course Code: PSBO (MPP) Title: Agro-Industrial Mycotechnology** **Course V**		
Course Code: PSBO (MPP)	**Title: Agro-Industrial Mycotechnology**	**Credit: 2**
Module 1	**Fungi in Agriculture** ➢ Mycorrhizal biofertilizer: Types of AM Fungi (Ectomycorrhiza, Endomycorrhiza, Ectoendomycorrhiza), General Morphology of any two commonly available AM fungi (*Acaulospora* , *Glomus),* Importance of AM Fungi as biofertilizer, Trap culture methods (Using Soil , Roots & spores) & Mass production of AM Fungi ➢ Microbial consortium for Composting: Role of Microbes in composting, Benefits of compost in Organic farming, Methods & process of composting, Application of compost, advantages of compost over chemical fertilizers	1
Module 2	**Fungi in bioremediation & Value added products** ➢ Bioremediation, Mycoremediation, Economical & environmental importance of bioremediation, Role of Lignolytic fungi and Basidiomycetes in bioremediation ➢ Value added products: Utilization of Ganoderma and Mushrooms for nutritional and medicinal purposes, Mushroom delicacy with nutritional value, Improvement of shelf life of mushrooms (by Sun drying, air drying, oven drying & food dehydrator methods)	1

	SEMESTER III (Practical -I)	Credits
	External	**2**
PSBOP (MPP)	**General Mycology & Techniques**	
1	Preparation of buffers	
2	Determination of pKa	
3	Study of the following fungal types with reference to their systematic position thallus and reproductive structures: *Physarum, Achlya, Pythium, Pilobolus*.	
4	Isolation of water mold by baiting technique	
5	Growth characteristics of *Rhizopus* sp, *Phytophthora* sp, *Pilobolus* on different culture media (Any two)	
6	Qualitative and quantitative screening of fungi for hydrolysis of phosphate.	
	Internal	
1	Aseptic techniques and establishing pure cultures	
2	Preparation of artificial key based on appropriate characters	
3	Comparative study of Isolation of soil fungi by serial dilution method using pour plate and spread plate technique.	
4	Isolation of food fungi, storage grains, dry fruits, and cereal grains by ISTA technique	
5	Measurement of fungal growth by linear determination (days)	

	SEMESTER III (Practical-II)	
	External	
PSBOP (MPP)	**Plant Pathology and Medical Mycology**	**Credits 2**
1	Isolation of fungal pathogens from infected leaves/ wood/ phylloplane	
2	Study of the following diseases – i) Downy Mildew of Grapes ii) Loose smut of wheat iii) Banana bunchy top virus iv) Little Leaf of Brinjal	
3	Determination of antifungal activity of antifungal agent - Nystatin, Griseofulvin, Azoles (Any one)	
4	Minimum inhibition concentration of salt/ sodium benzoate on fungal culture	
5	Biostatistics: ANOVA-one way and Two way	
6	Randomized Block Design and Latin Square	
	Internal	
1	Causal agent, Symptoms, diagnosis and control measures of human and animal diseases – Candidiasis, Aspergillosis, Saprolegniosis	
2	Problems in Nomenclature	
3	Detection of Mycotoxins by Paper Chromatographic method	
4	Biostatistics: Hypothesis testing, Normal deviate test	
5	Collection of five fungal diseases on plants and submission	

	SEMESTER III (Practical- ELECTIVE)	
	External	
PSBOP (MPP)		**Credits 2**
1	Isolation of AM spore by wet sieving and decanting by Gerdeman and Nicolson.	
2	Estimation of root colonization by AM Fungi by Philips and Hayman method	
3	To set up Trap culture of AM Fungi by using root or soil	
4	Identification of fungi used in bioremediation: Rot fungi (*Coriolus sp*, *Ganoderma sp*), Litter decomposers *Chaetomium sp*)	
5	Comparative analysis of protein content of locally available mushrooms by Lowry's method (*Agaricus* and *Pleurotus)*	
6	Prepare any two delicacies from mushrooms giving emphasis on its nutritional value.	
	Internal	
1	To set up Trap culture of AM Fungi by using spores	
2	Identification of isolated AM fungal spore upto genera level by studying morphological characteristics.	
3	Make a dry preservation of mushrooms using various techniques studied by you.	
4	Preparation of compost using microbial culture	

Specialization: Mycology and Plant Pathology (MPP)

General Mycology & Techniques.

Course Code PSBO (MPP)	**Title of the Paper- General Mycology & Techniques Course No. 1**			
	1	**Fungal Systematic and Life history**	4	**1**
	2	**Fungal Genetics and Ecology**		**1**
	3	**Industrial Mycology**		**1**
	4	**Myco-Techniques**		**1**

Course outcomes

The students will be able to:

CO1: Understand the rules of nomenclature and apply them in field of research, describe the general characteristics of fungi from various groups and understand the diversity and economic importance of lichens

CO2: Explore fungal genetics and discuss the role of Yeast Artificial Chromosomes (YACs) in genetic engineering and their applications in fungal research. Identify and describe extremophilic fungi and their adaptations to extreme environments

CO3: Recognize the scope and importance of fungi and employ them in industrial applications

CO4: Characterize the cultural and morphological characteristics of fungi and apply molecular and biochemical techniques in fungal studies, utilize molecular approaches for fungal taxonomy, and employ bioinformatic tools for data interpretation.

Course Code	Topic	Credits: 4
PSBO (MPP)	**General Mycology & Techniques**	
MODULE 1	**FUNGAL SYSTEMATIC AND LIFE HISTORY** ➢ Rules of nomenclature (code of Botanical nomenclature), Species concept (Morphological and Phylogenetic), Fungal nomenclatural repositories e.g. Index Fungorum, Mycobank ➢ Systematic position and Life cycle of the following classes of fungi with emphasis on the given genera: Ascomycotina: *Chaetomium*, Basidiomycota: *Cyathus*, Deuteromycotina: *Colletotrichum* (as per Alexopoulos and Mims Classification) ➢ Lichens: morphology and anatomy of thallus, reproduction, ecological aspects, and economic importance.	**1**
MODULE 2	**FUNGAL GENETICS AND ECOLOGY** ➢ Study of fungal genetics with reference to *Neurospora* as model organism - One gene-One enzyme hypothesis ➢ Role of Yeast Artificial Chromosomes (YACs) in genetic engineering ➢ Extremophilic Fungi: Psychrophilic, Thermophilic and Halophilic fungi ➢ Anamorphic fungi- i) Nematophagous fungi ii) Entomogenus fungi	**1**
MODULE 3	**INDUSTRIAL MYCOLOGY** ➢ Role of fungi in industrial mycology– Scope and Importance ➢ Commercial fungal strain: selection, improvement, inoculum and their maintenance. ➢ Fermentation, Types of fermentation- batch, continuous and fed-batch. Alcohol, organic acid, and bio-pesticide production. ➢ Food Industry- SCP single cell protein- advantages and disadvantages	**1**
MODULE 4	**MYCO- TECHNIQUES** ➢ Cultural characteristics and Morphological characterization of fungi ➢ Molecular and biochemical approach of fungal studies (AGE, PAGE, PCR, MALDI-TOF) ➢ Molecular approach to fungal taxonomy- sequencing of ITS, LSU, Bioinformatical tools for data interpretation (ML and Bayesian analysis)	**1**

	➢ Extraction methods for secondary metabolites	

Plant Pathology and Biotechnology

Course Code PSBO (MPP)	**Title of the Paper- Plant Pathology and Biotechnology Course No. 2**			
	1	**Crop Pathology**	4	**1**
	2	**Seed Pathology**		**1**
	3	**Genetics of Plant Diseases**		**1**
	4	**Fungal Biotechnology**		**1**

Course outcomes

The students will be able to:

CO1: Identify the causal organism and describe the disease cycle and suggest preventive and control measures for disease management, Understand the nematophagous fungi, Assess the physiological parameters involved in crop improvement

CO2: Describe the seed borne disease, assess the seed borne pathogens and the disease symptoms, recommend strategies to overcome the seed borne fungal disease.

CO3: Recognize the genetics of pathogenicity, the molecular pathways involved and apply genetic engineering techniques in the field

CO4: Describe fungal biotechnology, Apply the principles for mycoremediation and biofuel production for sustainable environment.

Course Code	Topic	Credits: 4
PSBO (MPP)	**Plant Pathology and Biotechnology**	
MODULE 1	**CROP PATHOLOGY** ➢ Causal organism, Symptoms, Disease Cycle and Control measures- • Fungal Disease: Wilt of pigeon pea, Ergot of cereals • Bacterial disease: Bacterial wilt of cucurbits • Viral disease: Tobacco Mosaic Virus ➢ Root-knot Nematode: *Meloidogyne* sp. (Disease symptoms and control measures) ➢ Physiological plant diseases due to- Temperature, Soil moisture, Nutritional disorders	**1**
MODULE 2	**SEED PATHOLOGY** ➢ Introduction and economic significances of seed borne diseases ➢ Seed borne pathogens: Fungi and Bacteria ➢ Pathological Effects of Seed borne diseases- i) Seed abortion ii) Shrunken seeds & Reduced seed size iv) Seed rot v) Sclerotisation & Stromatisation vi) Seed discoloration v) Reduced or complete loss of germinability. ➢ Management of Seed borne diseases - i) Chemicals ii) Antibiotics iii) Biological control agents iv) Host – Resistance in disease management	**1**
MODULE 3	**GENETICS OF PLANT DISEASES** ➢ Effect of Pathogens on Plant Physiological Functions: Photosynthesis, Respiration, Translocation of water ➢ Genetics of Plant Disease: Resistance(R) genes of plants, Pathogenicity genes, Signal transduction between the pathogenicity genes and Resistance gene ➢ Genetic engineering in plant disease resistance: Disease resistance plants with plant derived genes, Pathogen derived genes, RNA silencing by Pathogen derived genes	**1**

MODULE 4	**FUNGAL BIOTECHNOLOGY** ➢ Myco-remediation: Concept, Species selection, advantages. ➢ Biofuel Production: Bio-ethanol, Biodiesel and Oil production. ➢ Pharmaceuticals: Antibiotic production (Penicillin)	**1**

(Open Elective)		
Course Code: PSBO (MPP)	**Title: Industrial Mycology**	**Credit: 2**
Module 1	Fungi in food and medicine	1
Module 2	Fungal enzymes, Fermentation and Myconanotechnology	1

Course Outcomes

On completion of the course student will be able to:

CO1:	comprehend the role of fungi in food and food production processes, bioconversion, and preservation, and their applications in the food industry; understand and analyse the medicinal properties of fungi with emphasis on bioactive compounds and their therapeutic potential.
CO2:	Acquire comprehensive understanding of the fungal enzymes and its production, learn the principles and techniques of fungal fermentation for enzyme production, understand the principles of myconanotechnology and its applications.

	Title of the Paper- Industrial Mycology			**Course No. Elective**
Course Code PSBO (MPP)	**1**	**Fungi in food and medicine** • Food Industry- fungi as health foods, traditional fungal foods (Shoyu, Miso, Sake, Tempeh) production of yeast biomass, Mycoproteins, fungi in cheese production and baking industry • Spoilage of food and fungal toxicity • Fungi in medicine: antibiotics, immune-suppressors, statins		**1**
	2	**Fungal enzymes, Fermentation and Myconanotechnology** • Industrial applications of fungal enzymes -i) Protease ii) Cellulase iii) Invertase iv) Phosphatases • Fermentation Industry- sources and methods of production of Vinegar and citric acid • Myconanotechnology: Introduction, applications and future prospects		

	SEMESTER IV (Practical -I)	**Credits**

	External	**2**
PSBOP (MPP)	**General Mycology & Techniques**	
1	Study of the following fungal types with reference to their systematic position, thallus, and reproductive structures: *Chaetomium*, *Cyathus*, *Colletotrichum*, Fusarium	
2	Isolation and quantification of genomic DNA	
3	Agarose Gel electrophoresis- separation of plasmid DNA	
4	Separation of amino acids by two dimensional chromatography	
5	Study of wood rotting fungi: i) *Pleurotus* ii) *Schyzophyllum* iii) *Auricularia* iv) *Hexagonia (Not covered in theory)*	
6	Visit to Research centre and Report submission	
	Internal	
7	Demonstration/ Identification of Nematophagous fungi, Entomogenus fungi	
8	Exploration to fungal Nomenclature repository - Index Fungorum	
9	Utilization of MycoBank for Fungal Taxonomy Research	

	SEMESTER IV (Practical- II)	
	External	
PSBOP (MPP)	**Plant Pathology and Biotechnology**	**Credits2**
1	Study of different symptoms of plant diseases: i) TMV ii) Wilt of pigeon pea iii) Ergot of cereals iv) Bacterial wilt of cucurbits v) Root knots	
2	To study effect of different nitrogen sources on fungal growth in term of biomass	
3	Study of effect of relative humidity on fungal growth ($CaSO_4.5H_2O$ - 98%, KCl-85% & $CaNO_3.4H_2O$ -52%)	
4	Micrometry: Measurement of spores of fungal pathogens	
5	Bioinformatics: • Multiple sequence alignment • Phylogenetic tree	
	Internal	
1	Determination of antibacterial activity of *Penicillium*	
2	Light as physical factor influencing fungal growth & sporulation	
3	Study of Seed Surface Mycoflora from Seeds by Agar Plate technique	
4	Filing a Patent	

	SEMESTER IV (Practical- ELECTIVE)	
	External	
PSBOP (MPP)		**Credits 2**
1	Preparation of slants by Sub-culturing of fungal culture from pour plate culture /slide culture	
2	Isolation and detection of organic acid from fungal culture	
3	Immobilization of fungi and biodegradation of azo dye using fungal alginate beads	
4	Synthesis of nanoparticles and characterization of nanoparticles by UV spectroscopy	
5	Identification of fungi (food and medicine)- mushroom, yeast, *Ganoderma*, *Penicillium*,	
	Internal	
1	Determination of cellulase enzyme activity by DNSA method	
2	Isolation and identification of fungi from spoiled fruits and vegetables	
3	Isolation of baker's yeast from sour dough	
4	Determination of cell number, viable count method (using pour plate and serial dilution technique).	

Note:

- A minimum of **Two** field excursions (with at least one beyond the limits of Mumbai / Local Area) for habitat studies are compulsory.
- Field work of not less than **eight hours** duration is equivalent to one period per week.
- Industrial visit / Institutional visit at least **One** per Semester are compulsory.

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18. Taxonomy of AM Fungi: B. F. Rodrigues & T. Muthukumar

19. Mushroom Cultivation in India: B.C. Suman & V.P Sharma

20. Manual of Indian Edible Mushrooms: R.P. Purkayashta, Aindrila Chandra

21. Mycoremediation : Fungal Bioremediation : Harbhajan Singh

22. Biofertilizers, Biocontrol agents & Biopesticides: Concepts & Applications: Aniket Patil, Dr. Sandeep Badgujar, Dr. Sandeep Wagh

23. Ahmed M. Abdel-Azeem Ajar Nath Yadav Neelam Yadav Minaxi Sharma Industrially Important Fungi for Sustainable Development Volume 2: Bioprospecting for Biomolecules, 2021

Molecular Biology, Cytogenetics and Biotechnology (Specialization 4)									
Exit option: PG Diploma (44 Credits) after Three Year UG Degree									
II	**6.5**	**Sem III**	Course 1 **Plant Biotechnology** Credits 4 Course 2 **Molecular Biology and Cytogenetics** Credits 4 Course 3 **Practicals based on Course I & II** Credits 4 (2+2) Course 4 **IPR and Entrepreneurship skills** Credits 2	**Credits 4 (2+2)** Course 1 **Genetic Counselling** OR Course 2 **From other Specialization**			4	22	**PG Degree After 3- Yr UG**
		Sem IV	Course 1 **Plant Biotechnology** Credits 4 Course 2 **Molecular Biology and Cytogenetics** Credits 4 Course 3 **Practicals based on Course I & II** Credits 4 (2+2)	**Credits 4 (2+2)** Course 1 **Standardization of Herbal drugs (theory)** OR Course 2 **From other Specialization**			6	22	
Cum. Cr. for 1 Yr PG Degree			**26**	**8**			**10**	**44**	
Cum. Cr. for 2 Yr PG Degree			**54**	**16**	**4**	**4**	**10**	**88**	

SEMESTER III				
Course I	**Title of the Paper- Plant Biotechnology**			
	Module		**credits**	
	1	Plant Tissue Culture I	4	**1**
	2	Plant Tissue Culture II		**1**
	3	Biotransformation		**1**
	4	Commercial aspects		**1**

Course outcomes: The students will be able to:
CO1: Get conceptual understanding of various techniques and processes of plant tissue culture andplant improvement
CO2: Demonstrate the strategies and measures for storage of germplasm, production of biochemicalsand to solve the problems in plant tissue culture
CO3: Acquire in-depth knowledge of Biotransformation in Freely suspended and Immobilized plantcell culture and apply the same.
CO4: Develop critical thinking about the design, principles and processes in Bioreactors as well asCommercial production of secondary metabolites and plant genetic Engineering.

Course I	**Topic: Plant Biotechnology**	**Credits:4**
Module 1	Plant Tissue culture I: • Micropropagation of floricultural and medicinal plants usingorganogenesis and embryogenesis. • Factors responsible for *in vitro* and *ex vitro* hardening. • Plant improvement through Somaclonal variations	**1**
Module 2	Plant Tissue culture II • Plant cell cultures as chemical factories: Cell suspension, enhancement of product formation using biotic and abiotic elicitors,immobilization, permeabilization and product recovery • Problems in plant tissue culture: contamination, phenolics and recalcitrants • In vitro storage of germplasm, Cryopreservation	**1**

Module 3	Biotransformation • Freely suspended plant cells, Immobilized plant cells and plantenzymes Biotransformation for Vanillin production from Capsicum cell cultures and Menthol production from *Mentha piperata* cell cultures • *Agrobacterium* mediated transformed root cultures: hair root biology,culture system and optimization	**1**
Module 4	Commercial aspects • Commercial production from plant cell: scaling up of cell cultures;Rosmarininc acid and Vinblastine production • Bioreactors: factors for bioreactor design, pneumatically agitated bioreactors, comparison of bioreactors, operating mode, batch, fed-batch, semicontinuous, two stage operation, continuous cultivation;Factors for growth in Bioreactors. • Commercialization of PTC in India: Trends and scope	**1**

Course II	**Title of the Paper-** Molecular Biology and Cytogenetics **Course. II**			
	Module		Credits	
	1	Cytology	**4**	**1**
	2	Cancer Biology		**1**
	3	Immune system		**1**
	4	Genetic Diseases		**1**

Course outcomes: Students should be able to:
CO1: Gain the learning and critical thinking of cell membrane, cell differentiation, Cell recognition and Protein Sorting in the cells
CO2: Understand the molecular mechanism of Cancer, multiplication and spread of cancer cells as well as analyse the relationship of Cancer and mutations.
CO3: Acquire the knowledge of Immune system and ImmModuley in Health & Disease
CO4: Analyse and evaluate the molecular basis of Genetic disorders, Biochemical disorders, sex linked disorders, cardiovascular disorders and pedigree analysis.

Course II	**Title: Molecular Biology and Cytogenetics**	**Credits**
		4
Module 1	Cytology • Cell membrane and permeability: Molecular models of cell membrane, cell permeability. Differentiation of cell membrane, intercellular communications, and gap junctions. Cell coat and cell recognition, cell surface proteins • Intercellular compartments and Protein sorting: Compartmentalization of cell, mechanism of protein sorting toorganelles: Mitochondria, chloroplast, peroxisomes, nucleus • Organization and function of mitochondrial and chloroplast genomes.	**1**

Module 2:	Cancer Biology • Cancer cells: Characteristics, formation, division, spread, treatment.Role of carcinogens: radiations, chemicals, oncogenic virus. • Molecular basis of cancer cell behaviour • Apoptosis: Intrinsic and extrinsic pathways	**1**
Module 3:	Immune System: • Phylogeny of immune system, innate and acquired Immunity, nature and biology of antigens, major histocompatibility, complex cells of immune system, regulation of immune responses. • Production of antibodies by plant cells and organs • Immunity in Health and Disease: Immunodeficiency and AIDS	**1**
Module 4:	Genetic Diseases • Genetic disorders, genetic counselling and gene therapy • Biochemical disorders, sex linked disorders, cardiovascular disorders • Pedigree analysis with respect to above disorders	**1**

Course III	Title of the Paper: Practicals based on Plant Biotechnology and MolecularBiology and Cytogenetics			
	I	Plant Biotechnology	4	2
	II	Molecular Biology and Cytogenetics		2

Course outcomes: Student will be able to

CO1: Apply the principles of plant tissue culture and cytogenetics

CO2: Perform and analyze callus samples for metabolite production, mitotic index and meiosis

CO3: Record observations using various instruments and analyze results

CO4: Apply the knowledge of Biostatistics in the Plant Biotechnology and Cytogenetics

Course Code	Title: Practical I (Based on Plant Biotechnology)	Credits 2
	External	
	1. Preparation of Buffers (Phosphate and Acetate) 2. Determination of pKa 3. Preparation of stock solutions of MS medium 4. Preparation of explants for micropropagation, using any plant part 5. Isolation of bioactive compounds from callus or any plant source using TLC. 6. Types of Bioreactors and study of stages for Hairy root culture technique (Identification) 7. Spectrophotometric analysis of Protein using BSA by Bradford method 8. Western Blotting technique (Identification)	
	Internal	
	1. Preparation of MS basal and defined medium 2. Surface sterilization methods in PTC 3. Callus induction and regeneration using suitable explant 4. Filing a patent	

Course Code	**Title: Practical II (Based on Molecular Biology and Cytogenetics)**	**Credits 2**
	External	
	1. Calculation of mitotic index using suitable material (*Allium cepa /Chlorophyton*) in treated and untreated samples 2. Isolation and quantification of Plant Genomic DNA using spectrophotometric method 3. Separation & visualisation of Plant Genomic DNA by AGE 4. Immunodiffusion by Ouchterlony & Mancini Method 5. ELISA technique (Direct, Indirect, Sandwich and Competitive) - Identification 6. Pedigree analysis of traits: autosomal dominant and recessive, sex linked, mitochondrial inheritance 7. Perform smear technique using suitable material (Meiosis) and identify various stages (*Allium/Tradescantia*) 8. Perform regression analysis using MS Excel (Protein analysis) 9. Perform one-way and two-way ANOVA **Internal** 1. Techniques used in cytogenetics (FISH, Flow cytometry, SKY) – Identification 2. Blood group testing – Slide Agglutination Method (ABO system) 3. Study of genetic Disorders 4. Book Review (The Emperor of All Maladies - Siddhartha)	

Course Code IV	Title of the Paper- IPR and Entrepreneurship skills			Course No. IV
	I	Intellectual Property Rights	2	1
	II	Entrepreneurship skills		1

Course Outcomes: Upon completing the course, students will be able to:
CO1: Comprehend the importance of Intellectual property Rights (IPR) and identify its various types
CO2: Recognize the necessity of patents and understand their current status in India
CO3: Develop foundational skills essential for entrepreneurship
CO4: Equip students with the mindset and knowledge required to succeed as entrepreneurs and contribute to economic growth and innovation.

Common to ALL Specializations Course IV		
Course Code:	**Title: IPR and Entrepreneurship skills**	**Credit:2**
Module 1	IPR: • Objectives, Process, Scope; different property rights; • IPR status in India; • TRIPS and Patent Laws; • Biopiracy and bioprospecting, geographical indicators,Advantages of IPR and some case studies	1
Module 2	Entrepreneurship skills: • Introduction, Need and Challenges • Types and characteristics of successful Entrepreneurs • Factors affecting Entrepreneurship and factors to start business • Case studies – Write report (Atleast 2 cases from Specialization)	1

ELECTIVE

Course II	Title of the Elective Paper II- Genetic Counselling		Credits (2 +2)	
	Module		**Credit**	
	1	Basics of Genetic Counselling	**2**	**1**
	2	Chromosomal abnormalities and Genetic disorders		**1**

Course outcomes: On completion of the course students should be able to:

CO 1: Define Genetic Counselling and its Role
CO 2: Identify Types and Processes of Counselling
CO 3: Explain Genetic Disorders and Screening
CO 4: Analyze Ethical, Legal, and Social Issues

Course II	**Open Elective**	
Course Code:	**Title: Genetic Counselling**	**Credit: 2**
Module 1	Basics of Genetic counselling: • Introduction • Role of Counselor • Types of counselling (Individual, Family, Group) • Process of genetic counselling (information gathering, medical evaluation, diagnosis based on medical history)	1
Module 2	Chromosomal abnormalities and Genetic disorders: • Numerical and structural abnormalities and their causes of damage • Genetic disorders due to single gene, genomic imprinting, organelle genome, neurodevelopmental disorders • Scope of genetic screening: pre-natal, post- natal and adult • Ethical, legal and social issues	1

	Elective Practical : Genetic counselling	**Credits 2**
	External	
1	Study of Human karyotype manually and using online tool	
2	Pedigree signs and symbols used and basic pattern of inheritance	
3	Testing of colour vision deficiency using colour chart	
4	Construction of pedigree using manual and online tool	
5	Human fingerprint pattern analysis using arches, whorls, loops and ridge characteristics	
6	Pedigree analysis based on blood groups and solving problems based on it /	
7	Barr body testing from buccal cavity.	
8	Case studies and problems	
	Internal	
1	Complications in pedigree analysis (variable expressivity, heterogeneity, penetrance, anticipation, epigenetics, mosaicism)	
2	Non Mendelian Inheritance studies	
3	Calculation of allele frequency in population and estimation of carrier frequency	
4	Calculation of probability percentage for Thalassemia	
5.	Case studies and problem based on theory	

SEMESTER I

SEMESTER IV

Course I	**Title of the Paper- Plant Biotechnology**		**Credits 4**	
	Module		**Credits**	
	1	**Plant Genetic Engineering**	4	**1**
	2	**Bio-Nanotechnology**		**1**
	3	**Industrial Biotechnology**		**1**
	4	**Food and Environmental Biotechnology**		**1**

Course Outcomes: Upon successful completion of this course, the student will be able to:

CO1: Understand and apply the knowledge of Plant Genetic Engineering in the development of transgenics.

CO2: Analyze various methods used for characterization of nanoparticles and outline its applications.

CO3: Relate the fermentation process for the synthesis of industrial based products.

CO4: Discuss the applications of food and environmental biotechnology in different disciplines of biological sciences

Course Code I	**Title: Plant Biotechnology**	**Credits**
		4
Module 1	Plant Genetic Engineering: • Principles of Genetic Engineering: Cloning vehicles and Geneexpression vectors, Restriction enzymes, Host cells, Selectablemarkers and Reporter genes; transformation • Methods of gene delivery (Chemical and Biological methods)and selection of transformed cells (Blue white screening, fluorescence method, Antibiotic screening, PCR mediated, Southern Hybridization etc.) • Applications of Transgenic Plants: Abiotic stress tolerant (anyone)	**1**
Module 2	Bio-Nanotechnology • Characterization: (FTIR, SEM, TEM, STEM, Scanning Tunneling Microscope, Atomic Force Microscope, UV-Vis) • Green synthesis of nanoparticles: microbial & plant extracts; useof proteins and DNA templates • Applications: Nanoremediation and Cosmetics	**1**

Module 3	Industrial Biotechnology: • Fermentation technology: Downstream and Upstreamprocessing • Production of enzymes, ethanol, vitamins, vaccines Biosensors: components, types, uses	**1**
Module 4	Food and Environmental Biotechnology: • Functional foods (food fortification, prebiotic and probiotic) • GMOs: Concept and Food Safety and Environmental concernswith suitable examples Biosorption: use of fungi and algae; biomass of energy (biogas production)	**1**

Course II	Title of the Paper- Molecular Biology and Cytogenetics		Credits :4	
	Modules		Credits	
	1	Gene Regulation in Prokaryotes	4	1
	2	Gene Regulation in Eukaryotes		1
	3	Classical Plant Breeding and Mutation Breeding		1
	4	Molecular Plant Breeding		1

Course Outcomes

On completion of the course students should be able to

CO1: Understand the concept of gene regulation in prokaryotes and eukaryotes.

CO2: Apply the knowledge of gene regulation in operon, development of *Drosophila* and *Arabidopsis* and gene editing tools.

CO3: Explain the importance of classical plant breeding in selection process, distant hybridisation and in genetic manipulation.

CO4: Relate the molecular and mutation breeding technology in the various crop improvement programs.

Course II	Title: Molecular Biology and Cytogenetics	Credits 4
Module 1	**Gene Regulation in Prokaryotes:** • Gene concept and organization in prokaryotes • Regulations of gene expression in bacteria – lac operon, trp operon (Positive and negative regulation) • Regulation of gene expression in bacteriophage λ (lytic and lysogenic regulation)	**1**
Module 2	**Gene Regulation in Eukaryotes:** • Transcriptional control, RNA processing control, mRNA translocation control; mRNA degradation and protein degradation control • Genetic regulation of development in D*rosophila* and *Arabidopsis* • Gene editing tool: CRISPR technology	**1**
Module 3	**Classical Plant Breeding:** • Selection – mass, pure line and clonal • Hybridization techniques in self-pollinated and cross pollinated plants. • Genetic control and manipulation of breeding systems including male sterility and apomixes • Distant hybridization: Barriers to the production of distant hybrids and applications in crop improvement; Limitations of distant hybrids	**1**

Module 4	**Molecular and Mutation Plant Breeding** • Marker assisted selection using DNA-based molecular marker aided breeding: RAPD, RFLP, AFLP, Microsatellites and SNPs • DNA Sequencing methods: Next Generation Sequencing methods • Mutation Breeding: types, methods and detection (PCRmethods)	**1**

Course III	Title of the Paper: Practical based on Plant Biotechnology and Molecular Biology and Cytogenetics			Credit (2 +2)
	I	Plant Biotechnology	4	2
	II	Molecular Biology and Cytogenetics		2

Course outcomes: Student will be able to

CO1: Develop a practical understanding of the principles and techniques used in Plant Biotechnology, Molecular Biology and Cytogenetics

CO2: Critically analyze experimental results and correlate findings with practical applications in Plant Biotechnology

CO3: Gain hands-on experience on using Biostatistics and Bioinformatics tools to manage and interpret biological data sets

CO4: Demonstrate proficiency in laboratory skills

Course Code	Title: Practical I (Based on Plant Biotechnology)	Credits 2
PSBO	**External**	
	1. Separation of amino acids by 2D paper chromatography 2. Viscosity studies of proteins: standard BSA and varying concentrations of urea 3. Immobilization of yeast cells and study of invertase activity 4. Extraction and estimation of sugars (DNSA method) from ripe & unripe fruits 5. Bio-composting (pH, conductivity and organic matter content) 6. Cloning vectors (Ti and Ri plasmid) 7. Types of biosensors	
	Internal	
	1. Synthesis of nanoparticles and characterization of nanoparticles by UV spectroscopy 2. Anti-microbial activity of plant extracts by disc diffusion method/ well diffusion method/ MIC method 3. Bio-ethanol Fermentation set up (demonstration) 4. Southern Hybridisation (Demonstration)	

Course Code	Title: Practical II (Based on Molecular Biology and Cytogenetics)	Credits 2
	External	
	1. Preparation of culture medium (Nutrient agar medium/ LB medium) 2. Establishing pure cultures, streak plate method (T-streak and pentagon method), Pour plate, spread plate 3. Determination of cell number using haemocytometer (Yeast) 4. Separation of seed proteins using PAGE 5. Restriction enzyme digestion and separation of fragments using AGE (demonstration) 6. Transformation of *E. coli* by plasmid DNA and Blue white screening (demonstration) 7. Determination of viable pollens 8. Mutagen treated (PDB/MMS/EMS/Colchicine) mitosis in asuitable plant material 9. Study of *Arabidopsis* and *Drosophila* mutants 10. Bioinformatics: MSA and Phylogenetic tree	
	Internal	
	1. Aseptic techniques (microbial) 2. Determination of viable count method using serial dilution technique (spread plate) 3. Calculate Chiasma Frequency from the given photomicrograph *4.* Culturing of *Drosophila* 5. Chromosome banding techniques: Banding Techniques- Giemsa banding/ R- banding/ C- banding (Microphotographs) 6. Study of Molecular marker profiles: RAPD, microsatellites, AFLP, SNP 7. LSD and RBD analysis	

Course Code I	Title of the Elective Paper- Standardization of Herbal drugs			Course No. I
	Module		**Credits**	
	1	**Introduction to Herbal Drugs and Quality Control**	**2**	**1**
	2	**Regulatory Aspects and Future Trends in Herbal Drug Standardization**		**1**

Course Outcomes:

Upon completion of the course, students will be able to

CO1: Comprehend the principles and significance of standardizing herbal drugs to ensure quality, safety, and efficacy.

CO2: Navigate global regulatory frameworks and ethical considerations relevant to herbal drug standardization, preparing them for responsible practice in the industry.

Course Code I	**Standardization of Herbal drugs**	**Credits 2**
Module 1	**Introduction to Herbal Drugs** • Definition and classification of herbal drugs • Importance of standardization in herbal medicine • Quality Control of Herbal Medicines • Parameters of quality: identity, purity, potency, and safety • Methods for evaluating quality: macroscopic and microscopic analysis **Pharmacognostic Techniques** • Identification and characterization of herbal drugs • Use of chromatographic and spectroscopic techniques in herbal analysis • Case Studies and Practical Applications • Case studies on successful quality control and standardization processes	**1**
Module 2	**Regulatory Aspects and Future trends in Herbal Drug Standardization:** **Global Regulatory Frameworks:** • Overview of regulatory agencies (e.g., WHO, FDA) and guidelines for herbal drugs • Good Manufacturing Practices (GMP) for herbal products **Ethical and Legal Considerations:** • Ethical issues in herbal drug standardization • Legal aspects: patents, intellectual property rights, and international regulations • Current Trends and Innovations **Emerging technologies in herbal drug analysis and standardization** **Future directions and challenges in the field of herbal medicine**	**1**

	SEMESTER IV (Elective Practical) Standardization of Herbal drugs	Credits 2
	External	
1	Macroscopic and microscopic analyses to assess the identity, purity, and safety of herbal drugs, demonstrating proficiency in quality control techniques.	
2	Powder characteristics of herbal drugs	
3	Microbial load of herbal powders	
4	To perform preliminary phytochemical screening of crude drugs.	
	Internal	
1	Incorporation of prepared and standardized extract in cosmetic formulations like creams /lotions / shampoos and their evaluation. (Any 2)	
2	Monograph analysis of herbal drugs from recent Pharmacopoeias (Any 3)	

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Plant Physiology and Plant Biochemistry (Specialization 5)									
Exit option: PG Diploma (44 Credits) after Three Year UG Degree									
II	**6.5**	**Sem III**	Course 1 **Plant Physiology, Designing of Experiments and Biostatistics** Credits 4 Course 2 **Plant Biochemistry** Credits 4 Course 3 **Practicals based on Course I & II** Credits 4 (2+2) Course 4 **IPR and Entrepreneurship skills** Credits 2	**Credits 4 (2+2)** Course 1 **Plant Metabolism I** OR Course 2 **From other Specialization**			4	22	**PG Degree After 3- Yr UG**
		Sem IV	Course 1 **Plant Physiology** Credits 4 Course 2 **Plant Biochemistry** Credits 4 Course 3 **Practicals based on Course I & II** Credits 4 (2+2)	**Credits 4** Course 1 **Plant Metabolism II** OR Course 2 **From other Specialization**			6	22	
Cum. Cr. for 1 Yr PG Degree			**26**	**8**			**10**	**44**	
Cum. Cr. for 2 Yr PG Degree			**54**	**16**	**4**	**4**	**10**	**88**	

COURSE OUTCOME

COURSE CODE	TITLE AND LEARNING OUTCOMES
PSBO	After the successful completion of the course, the student will be able to: Explain mechanism of Solute transport and photo assimilate translocation, Describe Effect of drought and salt on metabolic processes, Mechanism of resistance avoidance and tolerance. Discuss physiology of flower and seeds, Use bio statistical techniques in plant experiments
PSBO	After completion of these course students will be able to: explain principles of catalysis, enzyme kinetics, structure of coenzymes, vitamins, compare primary, secondary and tertiary structure of protein, mechanism of protein folding, describe nucleotide metabolism, explain general principals and techniques of important instruments in plant physiology and biochemistry research.
PSBO	After completion of these course students will be able to explain scope and importance of plant physiology, discuss process of photosynthesis, C3, C4, CAM pathways., describe the process of respiration, growth and developmental process in plant, explain the regulation of basic physiological processes in plants
PSBO	After completion of course students will able to Describe Nitrogen and sulphur metabolism, explain importance of secondary metabolites in living plant system, discuss biosynthesis of aromatic acids in plants, explain importance and role of Nitrogen and sulphur metabolism

SEMESTER III				
Course Code PSBO	**Title Plant Physiology, Designing of Experiments and Biostatistics Course No. 1**			
	1	Solute transport and photo assimilate translocation	4	**1**
	2	Stress Physiology: Drought and Salinity		**1**
	3	Physiology of flowers and fruits		**1**
	4	Biostatistics		**1**

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

CO1: Explain mechanism of Solute transport and photo assimilate translocation

CO2: Describe effect of drought and salt on metabolic processes, Mechanism of resistance avoidance and tolerance

CO3: Discuss physiology of flower and seeds

CO4: Use bio statistical techniques in plant experiments

Course Code	**Plant Physiology, Designing of Experiments and Biostatistics**	**Credits: 4**
PSBO	**Topic**	
MODULE 1	**Solute transport and photo assimilate translocation** • The concept of water potential; • Uptake, transport and translocation of water, ions, solutes and macromolecules across membranes, • Transpiration; • Mechanisms of loading and unloading of photo assimilates	**1**
MODULE 2	**Stress Physiology: Drought and Salinity** • Morphological and cellular adaptations, mechanism of drought tolerance, • Role of Proline, Glycine Betaines, Mannitol, Pinitol and Osmotin in stress resistance. • Generic Pathway for Plant Response to Stress • Effect of salt on metabolic processes, Mechanism of Salt resistance- salt avoidance (exclusion, extrusion & dilution) and tolerance (Regulation of ion homeostasis by SOS pathway), • Role of Glycine Betaine and Proline in Salinity Stress, DEAD-Box Helicases in Salinity Stress Tolerance	**1**
MODULE 3	**Physiology of flowers and fruits** ● Physiological changes during ripening, fruit preservation ● Role of ethylene in post- harvest technology, ● Jasmonic acid ● Biological factors affecting the quality of fruits and vegetables.	**1**
MODULE 4	**Designing of Experiments and Biostatistics** • Randomized block Design and Latin square Design • Hypothesis testing (z test). • ANOVA- two way.	**1**

Course Code PSBO	Title of the Paper- Plant Biochemistry		Course No. II	
	1	Enzymes, Coenzymes and Vitamins	4	1
	2	Plant Proteins		1
	3	Nucleotide Metabolism		1
	4	Instrumentation		1

Course outcomes: After completion of these course students will be able to

CO 1: Explain kinetics of enzymes, and structure and physiological activities of coenzymes, and vitamins.

CO 2: Compare primary, secondary and tertiary structure of protein, and mechanism of protein folding

CO 3: Describe nucleotide metabolism

CO 4: Explain general principles and techniques of important instruments in plant physiology and biochemistry research.

Course Code	Title	Credits
PSBO	**Plant Biochemistry**	**4**
Module 1	**Enzymes, Coenzymes and Vitamins** • Principles of catalysis, enzymes and enzyme kinetics, enzyme regulation, mechanism of enzyme catalysis, Isozymes. • Structure, occurrence of all water soluble and fat soluble vitamins (types)and physiological activity • Coenzymes – Structure, occurrence, types, physiological activities, Genetic regulations	**1**
Module 2	**Plant Proteins** • Primary, Secondary and tertiary Structure of protein, • Protein folding and Ramachandran plot • Lectins and storage proteins in plants, transamination, oxidative deamination and urea cycle • Commercial application – Soya protein	1
Module 3	**Nucleotide Metabolism** • Biosynthesis and regulation of Purine • Biosynthesis and regulation of Pyrimidine • Recycling of Purine and Pyrimidine nucleotides by salvage pathways.	1
Module 4	**Instrumentation** • General principle and procedure involved in solid phase extraction and liquid -liquid extraction • Principle and techniques of UV- Visible Spectrophotometer, Fluorimeter, Flame photometer, Infra red gas analyzer • Principle and techniques of LC-MS /MS	1

Course Code PSBO	Title of the Paper-Practicals based on Course I & II			Course No. III
	1	Practicals based on Course I	2	1
	2	Practical based on Course II		1

Course Outcomes: The students will be able to:

CO1: Analyse and estimate different primary and secondary metabolites from plant.
CO2: Demonstrate competence in quantitative chemical analysis, specifically in the quantification using appropriate methods and techniques.

Course Code	Title	Credits
PSBO	Practicals based on Course I	2
Course I	**External:** 1. Enzyme kinetics: Effect of substrate variation on the activity of enzyme. Catalase/Peroxidase 2. Extraction and determination of purity of DNA by uv-spectrophotometer 3. Estimation of RNA by Orcinol method 4. Extraction and estimation of sugars from suitable ripe and raw plant material. 5. Extraction and estimation of polyphenols from suitable plant material. 6. Extraction and estimation of vitamin C from suitable plant material using spectrophotometer. 7. Estimation of proline in response to salt stress. **Internal:** 8. Determine the chlorophyll-a and chlorophyll-b ratio in C3 and C4 plants 9. Estimation of proline in response to temperature stress. 10. Qualitative tests for Lipids, Terpenes and Phenols.	1

	Practicals based on Course II	
	External: 1. Preparation of solution of different concentrations, Buffers, Conductivity and pH measurements 2. To study working principle of spectrophotometer and uses in biological analysis. 3. Estimation of total amino acid in germinating and non germinating seed 4. Estimation of Na content in garden and salt stressed plants. 5. Determination of pKa 6. Determination of scavenging enzymes activity of Peroxidase 7. Determination of scavenging enzymes activity of Catalase **Internal:** 1. Estimation of soluble proteins in germinating and non-germinating seed by Lowry and Bradford's method 2. To study principle and demonstration of Gel Electrophoresis 3. Demonstration of HPLC technique 4. Demonstration of Ion exchange chromatography 5. To study X-ray diffraction (Virtual mode) 6. Visit to laboratories.	1

Open Elective I
Advanced Plant Physiology

Course outcomes

After completion of these course students will be able to
CO 1: explain scope and importance of plant physiology.
CO 2: discuss process of photosynthesis, C3, C4, CAM pathways.
CO 3: describe the process of respiration, growth and developmental process in plant.
CO 4: explain the regulation of basic physiological processes in plants

(Open Elective) **Course Code: PSBO Title: Plant Metabolism Course V**		
Course Code PSBO	**Title: Plant Metabolism**	**Credit: 2**
Module I	**Photosynthesis**: Ultrastructure of chloroplast and light harvesting complexes, Energy transduction in photosynthesis, photosynthetic electron transport, ATP synthesis, photosynthetic pathway C3, C4 and CAM and their subgroups, C3 & C4 intermediates, regulation of Rubisco, PEP case and PCR cycle, photorespiration and its significance. photosynthetic carbon partitioning regulation of sugar and starch, biosynthesis	1
Module II	**Respiration**: regulation of glycolysis, pentose phosphate pathway and TCA cycle, modern concept of electron transport chain in plant mitochondria, alternate oxidase, respiratory inhibitors, Gluconeogenesis. Organic acid metabolism – metabolism and role of malic acid, oxalic acid and ascorbic acid.	1

	SEMESTER III Elective I (Practical)	
	External	**Credits 2**
PSBOPA		
1.	Estimation of Chlorophylls and Carotenoids, Chl a/Chl b Ratio from C3 and C4 plants.	
2.	Study of characteristics of CAM plants	
3.	Measurement of Rate of Respiration (In Germinating Seeds).	
4.	Study of Enzyme Glycolate Oxidase.	
5.	Determination of CO_2 Compensation Point.	
6.	Estimation of TAN (Titratable acid Number) from Bryophyllum leaves/Aloe vera.	
	Internal	
7.	Investigating Photosynthesis with a Controlled Environment Chamber	
8.	Compare Photosynthesis in different light intensities	
9.	Investigate the effect of temperature on Respiration	
10.	Measure the effect of CO_2 on Photosynthesis	
11.	Compare the rate of respiration in different plant tissues	

SEMESTER IV

Course Code PSBO	Title of the Paper- Plant Physiology		Course No. 1	
	1	Plant Growth Regulators	4	1
	2	Phytoremediation		1
	3	Sensory Photobiology		1
	4	Secondary Metabolism		1

Course outcomes

The students will be able to:

CO1: describe modulation of plant genomes by natural PGRs, uses of plant growth hormones and their mode of action

CO2: explain the concept of phytoremediation it's types.

CO3: discuss structure, function and mechanism of phytochromes cryptochromes and phototropins

CO4: explain biosynthetic pathways in the formation of secondary metabolites

Course Code	Course No. 1 Topic	Credits: 4
PSBO	**Plant Physiology**	
MODULE 1	**Secondary Metabolism** • General biosynthetic pathways in the formation of secondary metabolites • Biosynthesis and role of Phenols, Phenylpropanes, Coumarinns, lignins, flavonoids, alkaloids, tannins, and terpenes.	**1**
MODULE 2	**Plant Growth Regulators** • Modulation of plant genomes by natural PGRs- ▪ Auxins, ▪ Gibberellic Acid, ▪ Cytokinin ▪ Ethylene ▪ Abscisic Acid.	**1**
MODULE 3	**Sensory Photobiology** • Structure, function and mechanism of phytochromes cryptochromes and phototropins, • Phytochrome induced whole plant response, • Problems based on ABC model for flower organization	**1**

MODULE 4	**<u>Phytoremediation</u>** • Types of Phytoremediation – Advantages & limitations, • Remedial Measures - Rhizosphere based & Plant based, Hyper accumulators	**1**

Course Code PSBO	**Title of the Paper- Plant Biochemistry**		**Course No. II**	
	1	**Lipid metabolism**	**4**	**1**
	2	**Amino acid metabolism**		**1**
	3	**Cytosolic carbon and Mitochondrial metabolism**		**1**
	4	**Senescence**		**1**

Course outcomes

Students will be able to

CO1: Explain process of Lipid metabolism

CO2: Compare biosynthesis and regulation of prescribed Amino Acids

CO3: Describe cytosolic carbon and mitochondrial metabolism

CO4: Analyze pigment metabolism, protein metabolism and oxidative metabolism during senescence, programmed cell death

Course Code	Course No. II Title	Credits
PSBO	**Plant Biochemistry**	**4**
Module 1	**Lipid metabolism** • Synthesis and Function of membrane, structural & storage lipids, • odd and even carbon containing fatty acids of - o Omega fatty acids o Beta oxidation	**1**
Module 2	**Amino acid metabolism** • Biosynthesis of Amino Acids - ▪ Proline ▪ Glycine ▪ Aspergine ▪ Tryptophan ▪ Phenylalanine • Regulation of amino acid biosynthesis.	1
Module 3	**Cytosolic carbon and Mitochondrial metabolism** • Synthesis and breakdown of Sucrose and starch, • Regulation of Glycolysis and Gluconeogenesis. • Catabolic role of the TCA cycle, • TCA cycle regulation	1
Module 4	**Senescence** • Pigment Metabolism, Protein metabolism and oxidative metabolism during senescence. • Programmed cell death (PCD) an overview.	1

	SEMESTER IV (Practical I)	Credits
	External	**2**
PSBOP	**Experimental Plant Physiology**	
1	Estimation of Saponification & Iodine Value of Fats	
2	Estimation of Saponification & Iodine Value of Oil	
3	Separation and Measurement of Chlorophylls by Spectroscopy at different stages of Senescence.	
4	Separation and Measurement of Carotenoids by Spectroscopy at different stages of Senescence.	
5	Estimation of flavonoids using spectrophotometer	
	Internal	
1	Use of softwares for quantification of various phytochemicals	
2	Demonstration of spectrofluorometer	
3	Visit to a Phytoremediation plant and submission of report	
4	Ascorbic acid estimation in salt modulated plants	
5	Estimation of cytokinins from suitable plant material.	

	(Practical II)	
	External	
PSBOP	**Experimental Biochemistry**	**Credits 2**
1	Extraction & separation of Glucosinolates from Mustard	
2	Estimation of Piperine from *Piper*	
3	TLC of lycopene from *Lycopersicum*	
	Bioinformatics	
5	BLAST – pBLAST, nBLAST	
6	Multiple Sequence alignments: Phylogenetic tree (CLUSTAL W)	
7	Motif finding using any open source software	
	Internal	
1	Separation of lipids using Column Chromatography	
2	Isoenzyme separation using PAGE	
3	Separation of amino acids using HPLC	
4	Demonstration of Gas Chromatography	

Open Elective II

Plant Metabolism II

Course outcomes

After completion of course students will able to

CO 1. understand Nitrogen and sulphur Metabolism.

CO 2. know importance of secondary metabolites in living plant system.

CO 3. Understand biosynthesis of aromatic acids in plants

CO 4. Know Importance and role of Nitrogen and sulphur Metabolism.

(Open Elective) **Course Code: PSBO Title: Plant Metabolism Course V**		
Course Code: PSBO	**Title: Plant Metabolism**	**Credit: 2**
Module 1	**Nitrogen metabolism**: Overview of nitrogen fixation, Nitrate and ammonium assimilation	1
Module 2	**Sulphur Metabolism**: Sulphur chemistry and fixation, uptake and transport, reductive sulphate assimilation pathways, synthesis and function of glutathione and its derivatives.	1

	SEMESTER IV Elective II (Practical)	
PSBOPB	**External**	**Credits 2**
1	Effect of time and enzyme concentration on the rate of enzyme action (e.g. acid phosphatase, nitrate reductase).	
2	Estimation of stress using Glycine Betain	
3	Study of root nodules in leguminous plants	
4	Estimation of sulphur content from soil sample	
5	Determination of succinate dehydrogenase activity	
	Internal	
1	Isolation of Glucosinolates	
2	Isolation of *Rhizobium* from root nodules	
3	Isolation of Azotobacter	
4	Demonstration of nod genes through bioinformatics tools	
5	Field Visit	

Reference Books:

1. Biochemistry and molecular biology – Buchanan, Gruissem and Jones; I K International Delhi 2007.
2. Biochemistry Illustrated – Campbell and Smith – Churchill-Livingstone (Intenational Ed, 2000)
3. Lehninger – Principles of biochemistry – Nelson & Cox, Mac MillanWoth 3rd Ed. 2003.
4. Plant Biochemistry & Molecular Biology – Heldt – Oxford University Press, 1997.
5. Photosynthesis –A comprehensive treatise – Raghvendra A S, Cambridge University Press,
6. 2000. An introduction to plant biochemistry – Goodwin & Mercer, Pargamon Press, 1985.
12. Advanced Plant Physiology – Noggle& Fritz – Prantice – Hall of India.
13. Introductory Plant Physiology – Malcom Wilkins, Pitman Publication Ltd, 1984.
14. Plant Physiology – Pandey and Sinha, Vikas Publishing House, 1987.
15. Outlines of Biochemistry – Conn &Stumpf, John Willey and Co., 1987.
16. Plant Physiology, Biochemistry and Molecular Biology – Dennis and Turnip, longman
17. Scientific and Technical, 1990.
18. Plant Physiology – Taiz and Zeiger, Sinauer association Inc.
19. Practical biochemistry – David Plummer, MacGraw Hill.
20. Biochemical Methods – Sadasivan & Manickam, New Age International, 2009.

Reference Books:

Biostatistics and Bioinformatics

1. Biostatistics: A foundation For Analysis In Health Sciences (7th Edition 1999) Wayne W. Daniel John Wiley & Sons Inc.
2. Fundamentals of Biostatistics (2006) Veer Bala Rastogi Ane Books India
3. Biostatistics- The Bare Essentials (Second Edition 2000) Nosman Streiner B. C. Decker Inc.
4. Bioinformatics: Sequence and Genome Analysis (Second Edition 2004) David W. Mount Coldspring Harbor Laboratory Press
5. Bioinformatics and Functional Genomics (2003) Jonathan Pevsner John Wiley & Sons Publications

Evaluation Pattern:

External assessment: 50%

Internal assessment: 50%

Internal Assessment- 50%

Sr. No.	Evaluation type	Total Marks
1	One Assignments/Case study	20
2	Seminar	20
3	Group Discussion / Quiz / Test	10

External examination- 50%

a) **Semester End Theory Assessment- 50%** **50 Marks**

- Duration – These examinations shall be of **two hours** duration for each paper.

1. Theory Question Paper Pattern:

- There shall be five questions each of 10 marks.
- One question from each Module.
- Question No. 5 will be based on all 4 Modules.
- All questions shall be compulsory with internal choice within the questions.
- Each question will be of 15 to 20 marks with options.
- Question may be subdivided into sub-questions a, b, c… and the allocation of marks depend on the weightage of the topic.

2. Practicals: Two Practicals **(50 marks + 50 marks)**

University of Mumbai
M.Sc. BOTANY
Semester III / Semester IV
EXAMINATION Course PSBO

Maximum Marks: 50 **Duration: 2.00 Hours**

Question 1: Based on Module 1
Question 2: Based on Module 2
Question 3: Based on Module 3
Question 4: Based on Module 4
Question 5: Based on Module 1 to 4 (Mixed Questions)

Instructions:

1. All questions are compulsory.
2. All questions carry equal marks.
3. Draw neat and labelled diagrams wherever necessary.

1.Answer any **one** questions from the following. (Based on Module 1) (10 Marks)
   A.
   B.
   C.

2. Answer any **one** questions from the following. (Based on Module 2). (10 Marks)
   A.
   B.
   C.

3. Answer any **one** questions from the following. (Based on Module 3). (10 Marks)
   A.
   B.
   C.

4. Answer any **one** questions from the following. (Based on Module 4). (10 Marks)
   A.
   B.
   C.

5. Answer any **Two** questions from the following. (Based on all 4 Modules). (10 Marks)
   A.
   B.
   C.
   D.

Letter Grades and Grade Points:

Semester GPA/ Programme CGPA Semester/ Programme	% of Marks	Alpha-Sign/ Letter Grade Result	Grading Point
9.00 - 10.00	90.0 - 100	O (Outstanding)	10
8.00 - < 9.00	80.0 - < 90.0	A+ (Excellent)	9
7.00 - < 8.00	70.0 - < 80.0	A (Very Good)	8
6.00 - < 7.00	60.0 - < 70.0	B+ (Good)	7
5.50 - < 6.00	55.0 - < 60.0	B (Above Average)	6
5.00 - < 5.50	50.0 - < 55.0	C (Average)	5
4.00 - < 5.00	40.0 - < 50.0	P (Pass)	4
Below 4.00	Below 40.0	F (Fail)	0
Ab (Absent)	-	Ab (Absent)	0

Sign of the BOS Coordinator
Dr. Vasant Mali
BOS in Botany

Sign of the Offg. Associate Dean
Dr. Madhav R. Rajwade
Faculty of Science & Technology

Sign of the Offg. Dean
Prof. Shivram S. Garje
Faculty of Science & Technology