AC/24.02.2024/RS1

SIES College of Arts, Science & Commerce (Autonomous)

RISE WITH EDUCATION

NAAC REACCREDITED - 'A' GRADE

SIES College of Arts, Science and Commerce (Autonomous)
Sion (West) Mumbai: 400022

Affiliated to Mumbai University

Syllabus under Autonomy - June 2024

Program: M.Sc.

Syllabus for M.Sc. Part - II

Course: Botany

Choice Based Credit System (CBCS) Under NEP, 2020

With effect from the academic year 2024-25

PREAMBLE

In the revised autonomous syllabus under NEP, the committee has taken utmost care to maintain the continuity in the flow of information at M.Sc. level. Hence, some of the modules of the existing university syllabus have been upgraded with the new modules in order to introduce the learners to the recent developments in various branches of Botany.

All the papers of theory and practicals (Semester-III & Semester-IV together) are compulsory to the students.

Each theory period shall be of 60 minutes duration. Theory component shall have 165 instructional periods in semester III and IV. Each practical period shall be of 60 minutes duration. The core practical will be of 4 periods, whereas elective and practical will be of 2 periods. Projects will be allotted to students in the third semester. Students will complete pilot work and submit a project proposal at the end of semester III. In semester IV, students will continue with research project and submit the dissertation.

MODALITY OF ASSESSMENT:

Theory Examination Pattern

A) Internal assessment – Presentation and/or Class test + Class Participation

B) External examination – (Semester End Theory Assessment)

Practical Examination Pattern:

A. Internal Examination: There will not be any internal examination/ evaluation for practicals.

B. External (Semester end practical examination)

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination. In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head of the Department/ Co-

ordinator of the department; failing which the student will not be allowed to appear for the practical examination.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

After completing the post-graduation (M.Sc.) programme in Botany, the learners would be able to:

- **PSO1:** Identify the different groups of plants from Cryptogams to Phanerogams and gain the knowledge about inter-relationships, phylogeny, evolutionary concepts and plant biodiversity and its conservation.
- **PSO2:** Gain core knowledge of foundational concepts of plant taxonomy, anatomy, cytology, genetics, plant breeding, ecology and plant Physiology and biochemistry.
- **PSO3:** Understand the functioning of organisms at the genomic and cellular level. Critically evaluate the multi functionality of plant cells in production of fine chemicals & the industrial applications.
- **PSO4:** Analyse the molecular and physiological adaptations in plants in response to biotic and abiotic stress. Relate physiological adaptations, development, and reproduction of higher plants.
- **PSO5:** Apply the computational principles of biostatistics and bioinformatics to design experiments, analyses and interpret data to reach to an effective conclusion.
- **PSO6:** Use the plant tissue culture techniques for the propagation of the agriculturally or economically important plant to help the society /industry, apply the methods of *in vitro* techniques for product enhancement.
- **PSO7:** Evaluate & formulate novel herbal medicines based upon ethnobotanical studies, active constituents and traditional uses of plants with special reference to standardization of current herbal drugs.
- **PSO8:** Address the environmental issues with effective solutions. Follow ethical practices in environmental restoration. Apply technological advancements for better conservation & management of biodiversity.
- **PSO9:** Apply the principles of nanotechnology, environmental biotechnology and food biotechnology in various fields.

- **PSO10:** Understand the scope, current trends, job prospects and career avenues in Botany. Develop critical and logical thinking capacity and prepare themselves to qualify various competitive exams like MPSC, UPSC, SET, GATE, CSIR and UGC NET.
- **PSO11:** On job training will enable students to acquire new skills and hands-on industrial experience.
- **PSO12:** Contribute to current research and development work by applying experiential knowledge gained during the course period.

M.Sc. Semester III and IV Botany Syllabus (CBCS) Under NEP, 2020

To be implemented from the Academic year 2024-2025

SEMESTER III				
Course Code	**Unit No.**	**Unit Name**	**Credits**	**Lectures/ week**
SIPBOCC611	**Paper Title: Techniques and Instrumentation I**			
	I	**Biostatistics**	**4**	**1**
	II	**Bioinformatics**		**1**
	III	**pH, Buffers and Electrophoresis**		**1**
	IV	**Microscopy and Spectroscopy**		**1**
SIPBOCC612	**Paper Title: Molecular Biology I**			
	I	**DNA replication**	**4**	**1**
	II	**Transcription**		**1**
	III	**RNA processing**		**1**
	IV	**Translation**		**1**
SIPBOEL611	**Paper Title: Recent Trends and Applied Environmental Botany I**			
	I	**Conservation Ecology**	**3**	**1**
	II	**Biodiversity: Conservation and Management**		**1**
	III	**Renewable and Non-renewable Sources of Energy**		**1**
SIPBOCCP611	**Techniques and Instrumentation I**		**2**	**4**
SIPBOCCP612	**Molecular Biology I**		**2**	**4**
SIPBOELP611	**Recent Trends and Applied Environmental Botany I**		**1**	**2**
SIPBORP611	**Research Project**		**6**	**12**
SEMESTER IV				
Course Code	**Unit No.**	**Unit Name**	**Credits**	**Lectures/ week**
SIPBOCC621	**Paper Title: Techniques and Instrumentation II**			
	I	**Centrifugation**	**4**	**1**
	II	**Chromatography**		**1**
	III	**Tracer Technique and PCR**		**1**
	IV	**Nanotechnology and IPR**		**1**
SIPBOCC622	**Paper Title: Molecular Biology II**			
	I	**Gene Regulation in Bacteria and Bacteriophage**	**4**	**1**
	II	**Gene Regulation in Eukaryotes**		**1**
	III	**Epigenetics**		**1**
	IV	**Cell signalling**		**1**

SIPBOEL621	**Paper Title: Recent Trends and Applied Environmental Botany II**			
	I	**Restoration of Ecosystems**	**3**	**1**
	II	**Restoration of Land**		**1**
	III	**Watershed management**		**1**
SIPBOCCP621	**Techniques and Instrumentation II**		**2**	**4**
SIPBOCCP622	**Molecular Biology II**		**2**	**4**
SIPBOELP621	**Recent Trends and Applied Environmental Botany II**		**1**	**2**
SIPBORP621	**Research Project**		**6**	**12**

Semester III Paper I (Core)			
Course Code	**Course Title**	**Hr**	**Cr**
SIPBOCC611	**Techniques and Instrumentation I**	**60**	**4**

LEARNING OBJECTIVES:

The core course 'Techniques and Instrumentation' includes units on biostatistics; bioinformatics; pH, buffers and electrophoresis; microscopy and spectroscopy. The course aims to expose the students to hypothesis testing, different statistical tests, and their applications. It will also teach them about different types of databases, their organisation and analysis. The course will allow students to acquire various instrumentation techniques that are beneficial in biological research. It will enable students to understand the concept of pH and buffers.

COURSE OUTCOMES:

After completion of the course, the learners would be able to:
CO1: Acquire the basic skills required to perform computational analysis of biological data.
CO2: Apply various techniques in biostatistics as an analytical tool in the field of biological research.
CO3: Explain and apply the concepts of pH and buffers in the laboratory.
CO4: Illustrate the principles, working, and applications of microscopy and spectroscopy techniques, and utilize these techniques for the analysis of samples in biological research.

UNIT I – Biostatistics		**15**	**1**
1.	Hypothesis testing: Theory of errors – Type I and Type II errors, Null Hypothesis, z-test, Test of significance.		
2.	Introduction to ANOVA, One-way and two-way ANOVA.		
3.	Randomized Block Design and Latin Square Design.		
UNIT II – Bioinformatics		**15**	**1**
1.	Organization of biological data, databases (raw, processed, and specialized), and Queering in databases.		
2.	Exploration of databases, retrieval of desired data, BLAST etc.		
3.	Protein sequence analysis		
4.	Gene finding, motif finding and multiple sequence alignment.		
UNIT III – pH, Buffers and Electrophoresis		**15**	**1**
1.	pH and buffer solutions, concept of acids and bases, hydrogen ion concentration, dissociation of acids and bases, measurement of pH, and titration curves. Physiological Buffers.		

2.	Electrophoresis: Theory and applications		
3.	PAGE (Native and SDS) and AGE		
4.	2D Electrophoresis		
UNIT IV – Microscopy and Spectroscopy		**15**	**1**
1.	Microscopy: Principle, instrumentation, working and applications of fluorescence microscope, TEM, SEM. Biological sample preparation for electron microscopy.		
2.	Spectroscopy: Principle, instrumentation, working and applications of IR, AAS, Plasma Emission spectroscopy, NMR, MS.		

References:

1. Daniel, Wayne W., (1999), Biostatistics: A Foundation for analysis in Health Sciences, 7th edition, John Wiley and Sons Inc. Publ.
2. Mount D.W., (2004), Bioinformatics: Sequence and Genome Analysis, 2nd edition, Coldspring Harbour Laboratory Press.
3. Norman G.R., Streiner D.L., (1998), Biostatistics: The bare essentials, PMPH USA Ltd.
4. Pevsner J., (2003), Bioinformatics and Functional Genomics, John Wiley and Sons Inc. Publ.
5. Rastogi V.B, (2006), Fundamentals of Biostatistics, Ane Books India Pvt. Ltd.
6. Fluorescence Microscopy: From Principles to Biological Applications. (2017). Germany: Wiley.
7. Sharma, Y. R. (2007). Elementary Organic Spectroscopy. India: S. Chand Limited.
8. van Belle, G., Fisher, L. D., Heagerty, P. J., Lumley, T. (2004). Biostatistics: A Methodology For the Health Sciences. Germany: Wiley.
9. Khan, I. A., Khanum, A. (2004). Fundamentals of Biostatistics. India: Ukaaz.
10. Banerjee, P. K. (2007). Introduction to Biostatistics (A Textbook of Biometry). India: S. Chand Limited.
11. Govindarajan, R., Tejas, V., and Pushpangadan, P. (2019). High-performance liquid chromatography (HPLC) as a tool for standardization of complex herbal drugs. Journal of AOAC International, 102(4), 986-992.
12. Cañigueral, S., Arruda Frommenwiler, D., Reich, E., and Vila, R. (2018). "High performance thin-layer chromatography (HPTLC) in the quality control of herbal products," in Recent advances in pharmaceutical Sciences VIII. Editors D. Muñoz-Torrero, Y. Cajal, and J. M. Llobet (Kerala: Research Signpost), 119–136.

Semester III Paper I (Core) Practical			
Course Code	**Course Title**	**Hr**	**Cr**
SIPBOCCP611	**Techniques and Instrumentation I**	**4**	**2**

LEARNING OBJECTIVES:

1. It will also enable students to apply analysis of variance (one-way and two-way ANOVA) in problem-solving.
2. The course will assist the students in laying out and solving problems concerning Randomized Block Design and Latin square.
3. It will polish the computational skills of students through experiments based on bioinformatics like Multiple Sequence Alignments through the construction of phylogenetic tree.
4. The course will enable students to perform bioinformatic analysis using BLAST.
5. It will throw light upon the concept of Motif findings using bioinformatic tools.

6. The course will assist the students in the preparation of buffers and determination of pKa.	
COURSE OUTCOMES: After completion of the course, the learners would be able to: **CO1:** Layout and solve problems based on ANOVA, RBD and LS. **CO2:** Perform multiple sequence analysis crucial for the construction of phylogenetic tree and study evolutionary relationships among different species. **CO3:** Explore and apply methods for BLAST and motif findings. **CO4:** Prepare buffer solutions and determine pKa value by titration curve.	
1.	Application of analysis of variance (ANOVA) one-way and two-way
2.	Randomized Block Design and Latin Square Design
3.	Multiple alignments – phylogenetic tree
4.	BLAST
5.	Motif finding
6.	Preparation of Buffers –Phosphate and Acetate
7.	Study of titration curve and determination of pKa

Semester III Paper II (Core)			
Course Code	**Course Title**	**Hr**	**Cr**
SIPBOCC612	**Molecular Biology I**	**60**	**4**
LEARNING OBJECTIVES: The core course 'Molecular Biology' includes replication, transcription, RNA processing and translation units. The course aims to expound on molecular mechanisms of DNA replication with recombination, transcription with RNA processing and translation with post-translational modifications.			
COURSE OUTCOMES: After completion of the course, the learners would be able to: **CO1:** Comprehend molecular details of DNA replication in both prokaryotes and eukaryotes, along with an understanding of the assembly of DNA into nucleosomes and DNA recombination. **CO2:** Illustrate the process of transcription in prokaryotes and eukaryotes and explain the classes of RNA. **CO3:** Describe the mechanism of capping, polyadenylation, splicing pathways of different types of introns, RNA localization and regulation of gene expression by riboswitches. **CO4:** Explain the principle and process of translocation in prokaryotes and eukaryotes along with post-translational modifications.			
UNIT I – DNA Replication		**15**	**1**
1.	Assembly of raw DNA into nucleosomes		
2.	Molecular details of DNA replication in prokaryotes and eukaryotes.		
3.	DNA recombination, Holliday model for recombination.		
UNIT II – Transcription		**15**	**1**
1.	Transcription, RNA synthesis, classes of RNA and the genes that code for them.		
2.	Transcription of protein-coding genes, prokaryotes and eukaryotes, mRNA molecule.		
3.	Transcription of other genes, ribosomal RNA, and ribosomes, tRNA		
UNIT III – RNA processing		**15**	**1**

1.	Capping, polyadenylation, splicing, introns, and exons.		
2.	snRNA - Types, snRNA in the spliceosome, significance of snRNA		
3.	Non-coding RNAs, ribozyme, riboswitches, RNA localization.		
UNIT IV – Translation		**15**	**1**
1.	Protein structure, nature of genetic code, translation of genetic message.		
2.	Post translational modifications, protein localization, chaperons.		

References:

1. Russell PJ (2001) iGenetics: A Molecular Approach. Pearson Publ.
2. Krebs, J. E., Goldstein, E. S., Kilpatrick, S. T. (2017). Lewin's Genes welve. Japan: Jones and Bartlett Learning.
3. Nelson, D. L., Cox, M. M. (2017). Lehninger Principles of Biochemistry. India: W. H. Freeman.
4. Alberts, B. (2017). *Molecular biology of the cell*. Garland science.
5. Lodish, H. F., Berk, A., Kaiser, C., Krieger, M., Bretscher, A., Ploegh, H. L., ... and Amon, A. (2021). *Molecular cell biology*. New York: WH Freeman.

Semester III Paper II (Core) Practical			
Course Code	**Course Title**	**Hr**	**Cr**
SIPBOCCP612	**Molecular Biology I**	**4**	**2**

LEARNING OBJECTIVES:

1. The course will assist students in establishing pure cultures by various standard methods thereby enhancing their skills in the field of microbiology and maintaining cultures by different methods.
2. It will aid students in determining the number of viable yeast cells using methylene blue.
3. The course aims to isolate genomic DNA from plant material and quantify it using standard methods.
4. The course will help to perform and demonstrate the technique of polyacrylamide gel electrophoresis for the separation of proteins.
5. It will help students understand the concept of two-dimensional gel electrophoresis and the eastern blot transfer technique.

COURSE OUTCOMES:

After completion of the course, the learners would be able to:
CO1: Establish pure cultures and explain methods of maintenance of cultures.
CO2: Use a haemocytometer and determine the cell number of the viable yeast cells using methylene blue.
CO3: Isolate and quantify genomic DNA from plant material.
CO4: Carry out polyacrylamide gel electrophoresis for separation of proteins.
CO5: Demonstrate one- and two-dimensional gel electrophoresis and eastern blot transfer technique.

1.	Study of methods of culturing for establishing pure cultures: streak plate method- T streak, pentagon method, pour plate spread plate, serial dilution method.
2.	Maintenance of cultures by different methods.

3.	Determination of cell number of the viable yeast cell using methylene blue.
4.	Isolation and quantification of genomic DNA.
5.	Separation of proteins using PAGE.
6.	Analysis of proteins by one- and two-dimensional gel electrophoresis.
7.	Study of eastern blot transfer technique.

Semester III Paper I (Elective)			
Course Code	**Course Title**	**Hr**	**Cr**
SIPBOEL611	**Recent Trends and Applied Environmental Botany I**	**45**	**3**

LEARNING OBJECTIVES:

The elective course 'Recent Trends and Applied Environmental Botany I' in semester III includes units on Conservation Ecology, Biodiversity: Conservation and Management and Renewable and non-renewable sources of energy. The course aims to expose the students to various conservation techniques and role of national and international organizations and conventions in the field of environmental conservation. The course will provide knowledge of biodiversity concerning concept, levels, status, and role in ecosystem function and stability. It will also highlight the conservation and management aspects of biodiversity. The course will also help to study in detail about renewable and non-renewable sources of energy.

COURSE OUTCOMES:

After completion of the course, the learners would be able to:

CO1: Understand the role of national and international organizations, conventions, and legislations in ecosystem conservation; explain the procedures and significance of Environmental Impact Assessment (EIA) for sustainable development; and analyze various aspects and practical issues related to soil conservation.

CO2: Develop an understanding of biodiversity, including approaches to its conservation and management, with examples such as forest conservation movements, and appreciate the significance of crop diversity and the conservation of wild plant genetic resources.

CO3: Explore the requirements of energy resources for mankind by examining the advantages and disadvantages of renewable and non-renewable sources, with emphasis on their sustainable use, including the importance and practicality of biofuel production for environmental benefit.

UNIT I – Conservation Ecology		**15**	**1**
1.	**Role of National and International Organisations in Conservation and Some relevant terms:** UNDP, WWF, CSIR, TRIPS.		
2.	**Legislations** Aiming at Conservation (Objectives and penalties): Environment Protection Act 1986, Forest Conservation Act 1980, Wildlife Protection Act 1972.		
3.	**Conventions**: Earth summit, Vienna Convention, Ramsar Convention, Protocol: Montreal protocol, Cartagena protocol.		
4.	**EIA**- Environmental Impact Assessment-Types, Benefits, Process Monitoring and Evaluation. Role of Botanists in EIA and EMP; Environmental Impacts Assessment.		
5.	**Soil Conservation** - Definition, Causes and Types of Erosion; Conservation and Management of Eroded Soils/Areas, Wind Breaks, Shelter Belts; Sand Dunes; Reclamation of Saline and Alkaline Soils, Waste Lands.		
6.	**Ecotourism**		

UNIT II – Biodiversity: Conservation and Management		**15**	**1**
1.	**Biodiversity**: Definitions, Concept, Distribution at global and national level.		
2.	**Threats to biodiversity**: Causes for loss of biodiversity, IUCN categories of threats to biodiversity.		
3.	**Conservation of biodiversity**: *In-situ* – PAN (Biosphere reserves, National Parks, Sanctuaries), sacred groves; *Ex-situ* - Botanical gardens, Germplasm banks; Forest Conservation – Chipko and Appiko movements.		
4.	**Biodiversity Management Approaches**: Centres of Origin of crops; Plant genetic resources – Exploration and Collection, Crop domestication, Plant introductions; Threatened and Endangered plant species in India; Man and Biosphere Program (MAB)		
UNIT III – Renewable and Non-renewable Sources of energy		**15**	**1**
1.	Concept and Demand of Energy, Growing Energy Needs, Renewable and Non-Renewable Sources.		
2.	Alternate Energy Sources: Wind Energy, Solar Energy, Water as Source of Energy, Nuclear and Geothermal energy.		
3.	Biofuel production, Petro crops and energy plantations.		

References:

1. Agarwal S.K., (2003), Nuclear Energy – Principles, practice and prospects, APH Publishing Corporation.
2. Chapman J.D., (1989) Geography and Energy – Commercial energy systems and national policies; John Wiley and Sons Publ.
3. Chaturvedi P., (1995) Bio Energy Resources- Planning, Production and Utilization; Concept Publishing Company.
4. Dakshini K.M.M. (1999) Principle and Practices in Plant Ecology, CRC, Boston.
5. Dash M.C. (1994) Fundamentals of Ecology, Tata McGraw Hill, New Delhi.
6. Dayal M., (1989) Renewable Energy – Environment and Development, Konark Pub. Pvt. Ltd.
7. Enger E.D., Smith B.F., (2000) Environmental Science- A Study of Inter relationships, WCB Publ.
8. Ghosh Roy M.K., (2011) Sustainable Development, Ane books Pvt. Ltd.
9. Glasstone S., (1967) Sourcebook on Atomic Energy, 3rd edition, Van Nostrand Publ, Germany.
10. Vandana S., (2002) Alternative Energy- Applied Microbiology, APH Publishing Corporation.
11. Glasstone S., (1967) Sourcebook on Atomic Energy, 3rd edition, Van Nostrand Publ, Germany

Semester III Paper I (Elective) Practical			
Course Code	**Course Title**	**Hr**	**Cr**
SIPBOELP611	**Recent Trends and Applied Environmental Botany I**	**2**	**1**

LEARNING OBJECTIVES:

1. The course provides insight into the technique for studying plant communities. It enables them to discern the biodiversity of a community by calculating various diversity indices.
2. It will assist students in identifying endangered plant species in India.
3. The course will enable students to characterize biomass by proximate analysis that will help in selection of best feedstock and processing methods for biomass energy generation.

4. It will aid in interpreting different satellite imageries based on recent areas using various colour codes to throw light on the difference between the past and present features of that area.
5. The course will enable students to explore the various protected area network across different states and union territories of India by map plotting along with their biodiversity and conservation aspects.
6. It will aid students in determining sulphates in a given water sample and suspended, volatile and fixed solids in the sample.

COURSE OUTCOMES:

After completion of the course, the learners would be able to:
CO1: Calculate Diversity Indices in Plant Communities.
CO2: Identify the endangered plant species in India.
CO3: Characterize biomass by proximate analysis.
CO4: Interpret the satellite imagery.
CO5: Prepare maps of the biosphere reserves of India.
CO6: Determine sulphates in a given water sample and suspended, volatile and fixed solids in the sample.

1.	Calculation of Diversity Indices in Plant Communities.
2.	Identification of endangered plant species in India.
3.	Characterization of biomass – proximate analysis.
4.	Preparation of maps of Biosphere Reserves of India.
5.	Interpretation of satellite imagery, using recent images of familiar areas.
6.	Determination of sulphates in given water sample.
7.	Determination of suspended, volatile, and fixed solids.

Course Code	Course Title	Hr	Cr
SIPBORP611	**Research Project**	**12**	**6**

LEARNING OBJECTIVES:
Projects will be allotted in the third semester and students will submit a project proposal with having introduction, review of literature, well-defined material and methods, expected results and references. Project (To be selected by the student by carrying out the detailed review of the literature.)

COURSE OUTCOMES:
After completion of the course, the learners would be able to:
CO1: Carry out detailed literature review and assess the current state of research, thereby selecting a project topic.
CO2: Determine methodologies used in previous studies of similar topics.
CO3: Identify the issues that must be addressed within the framework of the specific proposal to take into consideration, all relevant dimensions of sustainable development.

Project (To be selected by the student by carrying out a detailed review of the literature. At the end of the semester students will submit a project proposal for the project and present it at the time of evaluation.)

Semester IV Paper I (Core)			
Course Code	**Course Title**	**Hr**	**Cr**
SIPBOCC621	**Techniques and Instrumentation II**	**60**	**4**

LEARNING OBJECTIVES:

The core course 'Techniques and Instrumentation II' includes units on centrifugation, chromatography, tracer technique, PCR, nanotechnology and IPR. The course aims to demonstrate chromatography and centrifugation techniques. It will further help them to explore principles, instrumentation, and applications of tracer techniques in biology. It will enable students to learn the process of IPR; and explore methods of biosynthesis of nanoparticles and techniques of characterization.

COURSE OUTCOMES:

After completion of the course, the learners would be able to:

CO1: Learn the basic principles of sedimentation and centrifugation, separation of various biomolecules by using different centrifuges as well.

CO2: Apply various techniques of chromatography for separation of biomolecules in research and in industries.

CO3: Demonstrate and apply concepts of radioactivity as well as get a better understanding of tracer techniques and instruments used in Biology.

CO4: Explain the knowledge regarding biosynthesis, characterization of nanoparticles and Intellectual Property Rights.

UNIT I – Centrifugation		**15**	**1**
1.	Basics principle of Sedimentation		
2.	Types of rotors		
3.	Differential and density gradient centrifugation		
4.	Preparative and Analytical centrifugation		
5.	Introduction to ultracentrifugation.		
UNIT II – Chromatography		**15**	**1**
1.	General Principle of Chromatography.		
2.	Techniques and applications of Ion exchange, Affinity Chromatography, HPLC and HPTLC		
3.	HPLC: A tool for standardization of complex herbal drugs.		
4.	HPTLC in the quality control of herbal products.		
UNIT III – Tracer Techniques and PCR		**15**	**1**
1.	Pattern and rate of radioactive decay, Units of radioactivity.		
2.	Principle, instrumentation, and technique: Geiger-Muller counter, Liquid scintillation counters and Autoradiography		
3.	Applications of isotopes in biology: Tracer techniques and Autoradiography		
4.	PCR and its applications		
UNIT IV – Nanotechnology and IPR		**15**	**1**
1.	Synthesis of nanoparticles using biological samples.		
2.	Characterization of nanoparticles (FTIR, SEM, TEM, STEM, Scanning Tunnelling Microscope, Atomic Force Microscope, UV-Vis.).		
3.	IPR: Objectives, process and scope		

References:

1. Singh, B. (2022). Plant Breeding: Principles and Methods. India: Scientific International.
2. Green Synthesis, Characterization and Applications of Nanoparticles. (2018). Netherlands: Elsevier Science.
3. Glick, B. R., Pasternak, J. J. (1994). Molecular Biotechnology: Principles and Applications of Recombinant DNA. India: ASM Press.
4. Murty, B., Shankar, P., Raj, B., Rath, B. B., Murday, J. (2013). Textbook of Nanoscience and Nanotechnology. Germany: Springer Berlin Heidelberg.
5. Spectroscopic Methods for Nanomaterials Characterization. (2017). Netherlands: Elsevier Science.
6. A Biologist's Guide to Principles and Techniques of Practical Biochemistry. (1986). United Kingdom: E. Arnold.
7. Bioinstrumentation: Tools for Understanding Life. (1996). United States: National Association of Biology Teachers, Incorporated.
8. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology. (2018). United Kingdom: Cambridge University Press.
9. Fundamentals and Techniques of Biophysics and Molecular Biology. (n.d.). (n.p.): Pathfinder Publication unit of PAPL.
10. Chatwal, G. R., Anand, S. K. (2002). Spectroscopy: Atomic and Molecular for B.sc Hons and M. Sc. Students of Indian Universities. India: Himalaya Publishing House.

Semester IV Paper I (Core) Practical			
Course Code	**Course Title**	**Hr**	**Cr**
SIPBOCCP621	**Techniques and Instrumentation II**	**4**	**2**

LEARNING OBJECTIVES:

1. The course will demonstrate the ion exchange chromatography of proteins to students.
2. It will enable students to carry out viscosity studies of proteins and perform two-dimensional chromatography for separation of amino acids.
3. The course will help students to understand the principles and methodology involved in the synthesis of nanoparticles, along with the characterization of nanoparticles by UV-visible spectroscopy.
4. It will explain the patent filing process in detail.
5. The students will gain exposure to research activities by visiting relevant Industries or Institutes and prepare a report based on it.

COURSE OUTCOMES:

After completion of the course, the learners would be able to:

CO1: Demonstrate the process of separation of proteins by Ion exchange chromatography.
CO2: Separate amino acids by two-dimensional chromatography.
CO3: Carry out viscosity studies of proteins with standard BSA and varying concentrations of urea.
CO4: Synthesize nanoparticles using plant extract and characterize nanoparticles using UV-visible spectroscopy.
CO5: Explain the steps involved in patent filing.
CO6: Prepare a report on industrial visit.

1.	Separation of proteins by Ion exchange chromatography.
2.	Separation of amino acids by two-dimensional chromatography.
3.	Viscosity studies of proteins: standard BSA and varying concentrations of urea.
4.	Synthesis of nanoparticles.
5.	Characterization of nanoparticles by UV-Visible spectroscopy.
6.	Filing a patent.
7.	Industrial visit and report submission.

Semester IV Paper II (Core)			
Course Code	**Course Title**	**Hr**	**Cr**
SIPBOCC622	**Molecular Biology II**	**60**	**4**

LEARNING OBJECTIVES:

The core course 'Molecular Biology II' includes units on gene regulation in bacteria and bacteriophage, gene regulation in eukaryotes, epigenetics, and cell signalling. The course will enable students to study the regulation of gene expression in bacteria and bacteriophage. The course will elaborate on control of gene expression in eukaryotes, epigenetics and concepts involved in cell signalling.

COURSE OUTCOMES:

After completion of the course, the learners would be able to:
CO1: Explain the concepts of regulating gene expression in bacteria and bacteriophages.
CO2: Illustrate the gene expression in eukaryotes to various control mechanisms.
CO3: Understand the concept of epigenetics and its role in human diseases.
CO4: Elucidate unicellular and multicellular organisms' response to chemical and physical signals.

UNIT I – Gene Regulation in Bacteria and Bacteriophage		**15**	**1**
1.	Regulations of gene expression in bacteria – *trp* operon, *ara* operon, *his* operon.		
2.	Regulation of gene expression in bacteriophage λ.		
UNIT II – Gene Regulation in Eukaryotes		**15**	**1**
1.	Control of gene expression in eukaryotes, Transcriptional control, RNA processing control, mRNA translocation control, mRNA degradation control, protein degradation control		
UNIT III – Epigenetics		**15**	**1**
1.	Epigenetics: Introduction; Mechanism		
2.	Epigenetic Regulation in Plant Responses to the Environment		
3.	Dosage Compensation in *Drosophila*		
4.	Epigenetics and Human Disease; Epigenetic Determinants of Cancer.		
UNIT IV – Cell Signalling		**15**	**1**
1.	Forms of signalling (autocrine, endocrine, paracrine (e.g. synaptic signalling) and cell-to-cell contact)		
2.	Hormones and their receptors, cell surface receptors, intracellular receptors, signal relay pathways-signal transduction pathways, second messengers, regulation of signalling pathways.		

3.	Bacterial and plant two-component systems, light signalling in plants, bacterial chemotaxis, and quorum sensing.		

References:

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2. Paro, R., Grossniklaus, U., Santoro, R., and Wutz, A. (2021). *Introduction to epigenetics* (p. 215). Springer Nature.
3. Alberts, B. (2017). *Molecular biology of the cell*. Garland science.
4. Latchman, D. S. (1992). Gene regulation. *BMJ: British Medical Journal*, *304*(6834), 1103.
5. Cooper Geoffrey M. And Hausman Robert E. (2009). The Cell – A Molecular Approach, 5th Edition, ASM Press and Sinauer Associates INC.
6. Taiz, L. and Zeiger, E. (2010) Plant Physiology. 5th Edition, Sinauer Associates, Inc., Sunderland.

Semester IV Paper II (Core) Practical			
Course Code	**Course Title**	**Hr**	**Cr**
SIPBOCCP622	**Molecular Biology II**	**4**	**2**

LEARNING OBJECTIVES:

1. The course will aid students in isolating and quantifying plasmid DNA.
2. It will help students to develop the skills required to separate plasmid DNA using the technique of agarose gel electrophoresis.
3. The course will guide students to perform restriction enzyme digestion and separate digested DNA fragments using agarose gel electrophoresis.
4. It will enable students understand gene expression in bacteria.
5. The course will enable students to understand the principle of β-galactosidase expression for screening of transformants and recombinants and the process of Southern blot transfer.

COURSE OUTCOMES:

After completion of the course, the learners would be able to:
CO1: Perform and demonstrate isolation and quantification of plasmid DNA.
CO2: Separate plasmid DNA using agarose gel electrophoresis.
CO3: Carry out restriction enzyme digestion and separation of DNA fragments.
CO4: Demonstrate the process of gene expression in bacteria.
CO5: Gain the insight of transformation of *E. coli* cells by plasmid DNA; β-galactosidase expression and assay.
CO6: Explain technique of Southern blotting.

1.	Isolation of plasmid DNA.
2.	Quantification of plasmid DNA.
3.	Separation of plasmid DNA using agarose gel electrophoresis.
4.	Restriction enzyme digestion and separation of fragments.
5.	Study of the process of gene expression in bacteria.
6.	Study of blue-white colony screening method for the detection of bacterial transformation and identification of recombinants.
7.	Study of Southern blot transfer technique.

Semester IV Paper I (Elective)			
Course Code	**Course Title**	**Hr**	**Cr**
SIPBOEL621	**Recent Trends and Applied Environmental Botany II**	**45**	**3**

LEARNING OBJECTIVES:

The elective course 'Recent Trends and Applied Environmental Botany II' in Semester IV includes units on restoration of ecosystems, restoration of land, and watershed management. The course will elaborate upon the importance of urban forestry and restoration of urban ecosystem. The course will give special emphasis on restoration methods for mangrove ecosystems. The course will highlight the increasing problems of solid waste management, wastewater management, and its necessity for the maintenance of land and soil. The course will explain the concept of construction and application of watershed management methods including various techniques of water-harvesting and conservation.

COURSE OUTCOMES:

After completion of the course, the learners would be able to:

CO1: Understand urban ecosystem, explore the role of urban forests and various restoration efforts in urban environments and acquire the knowledge of mangrove ecosystem restoration.

CO2: Obtain insight into the management of Municipal Solid Waste (MSW), biological treatment of wastewater from food processing industries and the new rules governing the same.

CO3: Gain knowledge about various aspects of watershed management and rehabilitation of degraded areas and explore the various methods of water harvesting and conservation with relevant case studies.

UNIT I – Restoration of Ecosystems		**15**	**1**
1.	**Urban Ecosystems**: ▪ Urban forestry and green belts. ▪ Role of gardens and parks. ▪ Urban issues and challenges – Transportation, Industrialization, Wastewater disposal in urban areas.		
2.	**Mangrove Ecosystems**: ▪ Mangroves of coastal Maharashtra. ▪ Selection and Treatment of Coastal Areas regarding Tidal situation and Physical Properties. ▪ Choice of Species, Collection of Seeds and Seedling Material, Storage, and Plantation for restoration. ▪ Problems of Seed Dormancy, Tidal Forces, Predation Nutrient Supply, and restoration methods.		
UNIT II – Restoration of Land		**15**	**1**
1.	Solid waste management: Classification of waste, Impact of solid waste on the environment, animals, plants, and human health; waste generation, separation and processing, waste treatment and disposal.		
2.	Management of municipal solid waste (MSW Rules 2016); Concept of Integrated Waste Management;		
3.	Biological treatment of wastewater from the food processing industry.		
4.	Biopesticides and integrated pest management.		
5.	Microbial transformation of heavy metals.		

UNIT III – Watershed Management		**15**	**1**
1.	Concepts of the watershed; the role of forests and forest trees in overall resource management, forest hydrology		
2.	Watershed development with respect to torrent control, river channel stabilization, avalanche and landslide controls, rehabilitation of degraded areas; hilly and mountain areas.		
3.	Watershed management and environmental functions of forests;		
4.	Water-harvesting and conservation; groundwater recharge and watershed management.		
5.	National Lake and River Conservation Programs; Implications of National River Linking programs on the environment.		

References:

1. Ghosh Roy M.K., (2011) Sustainable Development, Ane books Pvt. Ltd.
2. Gupta O.P., (2011) Aquatic weed, their maintenance and control; Agrobios Publ.
3. Ingegnoli V. (2002) Landscape Ecology: a widening foundation, Springer, Bonn.
4. Kormondi E.J. (1999) Concepts of Ecology, Prentice Hall of India, New Delhi.
5. Wolanski E, Day J, Elliot M, Ramesh R; (2009) Coasts And Estuaries, 1st edition, Elsevier Publ.
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7. Rai, S. C. (2017). Hydrology and Water Resources: A Geographical Perspective. India: Ane Books Pvt. Limited.
8. Kreb C.J. (1989). Ecological Methodology; Harper and Row Publ, New York, USA.
9. Marco Amati, (2008), Urban Green Belts in the Twenty-first Century, Aldershot Ashgate Publ.
10. Misra R. (1968) Ecology work book; Oxford and IBH New Delhi.
11. Molles M.C. Jr. (1999) Ecology- Concepts and Application, McGraw Hill, New Delhi
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13. Odum E.P. and Barrett G. W. (2005) Fundamentals of Ecology, Thomson Asia Pvt. Ltd, Singapore.
14. Ingegnoli V. (2002) Landscape Ecology: a widening foundation, Springer, Bonn.

Semester IV Paper I (Elective) Practical			
Course Code	**Course Title**	**Hr**	**Cr**
SIPBOELP621	**Recent Trends and Applied Environmental Botany II**	**2**	**1**

LEARNING OUTCOMES:

1. It will create awareness about the common mangrove species around the city through field studies.
2. The course will help to assess foliar dust capturing capacity of different trees in urban areas and highlight its significance in urban ecosystems.
3. It will enable students to assess level of organic pollution in water bodies by determining chemical oxygen demand. It will help to understand the level of dust and air pollution in urban areas.

4. The course enables students to determine total residual chlorine in water, SVI of biological sludge and optimum coagulant dosage.

COURSE OUTCOMES:

After completion of the course, the learners would be able to:
CO1: Determine Chemical Oxygen Demand of water sample.
CO2: Explain different types of biogas plants and select the most suitable biogas plant for a specific purpose.
CO3: Determine amount of total residual chlorine in water.
CO4: Carry out comparative studies on foliar dust capturing capacity of plant species from polluted and unpolluted sites.
CO5: Determine SVI of biological sludge and optimum coagulant dosage.
CO6: Submit a report on mangrove studies.

1	Chemical Oxygen Demand Value of given water sample.
2	Study of different types of biogas plants.
3	Determination of the amount of total residual chlorine in water by starch iodide method.
4	Comparative study of foliar dust capturing capacity from different plant species (minimum five) collected from polluted and unpolluted sites.
5	Determination of SVI of biological sludge.
6	Determination of optimum coagulant dosage.
7	Study of mangrove ecosystem: Field report

Semester IV			
Course Code	**Course Title**	**Hr**	**Cr**
SIPBORP621	**Research Project**	**12**	**6**

LEARNING OBJECTIVES:

Projects will be evaluated in fourth semester and students will submit dissertation having chapters - introduction, review of literature, well defined material and methods, observed results with discussion, conclusion and references, etc.

COURSE OUTCOMES:

After completion of the course, the learners would be able to:
CO1: Contribute to current research and development work and also gain deeper insight into it.
CO2: Acquire and display the knowledge and skills required for independent work as a Master of Science in Botany.
CO3: Present the collected data as thesis, publication, and seminar presentation and know the value of research.

Project (Students will modify and/or add the tests/protocols as per the suggestions provided by examiners during the project proposal presentation in the previous semester, complete the project work, and submit the dissertation.)