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

## Specialization: Cytogenetics and Plant Biotechnology

## 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** |
| **SIPBOEL612** | **Paper Title: Cytogenetics** | | | |
| | **I** | **Cytology** | **3** | **1** |
| | **II** | **Cancer Biology** | | **1** |
| | **III** | **Immune System and Genetic Disorders** | | **1** |
| **SIPBOCCP611** | **Techniques and Instrumentation I** | | **2** | **4** |
| **SIPBOCCP612** | **Molecular Biology I** | | **2** | **4** |
| **SIPBOELP612** | **Cytogenetics** | | **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** |
| **SIPBOEL622** | **Paper Title: Plant Breeding** | | | |
| | **I** | **Plant Breeding** | **3** | **1** |
| | **II** | **Plant Genetic Engineering** | | **1** |

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|---|---|---|---|---|
| | **III** | **Molecular Plant Breeding (Transgenic Crops)** | | **1** |
| **SIPBOCCP621** | **Techniques and Instrumentation II** | | **2** | **4** |
| **SIPBOCCP622** | **Molecular Biology II** | | **2** | **4** |
| **SIPBOELP622** | **Plant Breeding** | | **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.

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|---|---|---|---|
| **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:**

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|---|---|
| After completion of the course, the learners would be able to:<br>**CO1:** Layout and solve problems based on ANOVA, RBD and LS.<br>**CO2:** Perform multiple sequence analysis crucial for the construction of phylogenetic tree and study evolutionary relationships among different species.<br>**CO3:** Explore and apply methods for BLAST and motif findings.<br>**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:**<br>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:**<br>After completion of the course, the learners would be able to:<br>**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.<br>**CO2:** Illustrate the process of transcription in prokaryotes and eukaryotes and explain the classes of RNA.<br>**CO3:** Describe the mechanism of capping, polyadenylation, splicing pathways of different types of introns, RNA localization and regulation of gene expression by riboswitches.<br>**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.

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|---|---|
| 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. |

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| 6. | Analysis of proteins by one- and two-dimensional gel electrophoresis. |
| 7. | Study of eastern blot transfer technique. |

| **Semester III Paper II (Elective)** | | | |
|---|---|---|---|
| **Course Code** | **Course Title** | **Hr** | **Cr** |
| **SIPBOEL612** | **Cytogenetics** | **45** | **3** |

**LEARNING OBJECTIVES:**

The elective course 'Cytogenetics' includes units on cytology, cancer biology and immune system and genetic diseases. The course aims to throw light on the concept of cell membrane and permeability; organization and function of mitochondrial and chloroplast genomes. The students will acquire knowledge about characteristics of cancer cells, carcinogens, formation of oncogenes and cancer treatment. The course aims to explicate fundamental concepts of the immune system; genetic disorders, genetic counselling, and gene therapy.

**COURSE OUTCOMES:**

After completion of the course, the learners would be able to:
**CO1:** Describe the structure of the cell membrane, its function, mechanism of cell division and PCD.
**CO2:** Explain about nature, development, causes and treatment of cancer; spread cancer awareness.
**CO3:** Summarize the different types of cells involved in the immune system and their roles in innate and adaptive responses, and analyse various biochemical, sex-linked, and cardiovascular disorders to understand their relevance in genetic counselling and gene therapy.

| **UNIT I – Cytology** | | **15** | **1** |
|---|---|---|---|
| 1. | 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. | | |
| 2. | Cell division and Apoptosis: Mechanism of Cell division, PCD. | | |
| 3. | Organization and function of mitochondrial and chloroplast genomes. | | |
| **UNIT II – Cancer Biology** | | **15** | **1** |
| 1. | Cancer cells: Characteristics, division, spread, treatment. | | |
| 2. | Carcinogens: radiations, chemicals, oncogenic viruses. | | |
| 3. | Cancer and mutations, reproductive properties of transformed animal cells in culture, oncogenes, proto-oncogenes, and their conversion. Oncogenes and growth factors. | | |
| **UNIT III – Immune System and Genetic Disorders** | | **15** | **1** |
| 1. | Cells of immune system, innate and acquired immunity, major histocompatibility complex, regulation of immune responses. | | |
| 2. | Immunity in Health and Disease: Immunodeficiency | | |
| 3. | Genetic counselling and gene therapy. | | |
| 4. | Genetic disorders: Xeroderma, Duchenne muscular dystrophy; Biochemical disorders: AKU, Albinism, Tay-Sachs syndrome, Lesch-Nyhan syndrome; Cardiovascular disorders: Familial dilated cardiomyopathy, DiGeorge syndrome, Marfan syndrome. | | |

**References:**

1. Hardin, J., Bertoni, G., Becker, W. M. (2018). Becker's World of the Cell. United Kingdom: Pearson.
2. Cooper Geoffrey M. And Hausman Robert E. (2009). The Cell – A Molecular Approach, 5th Edition, ASM Press and Sinauer Associates INC.
3. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. United Kingdom: Wiley.
4. Weinberg, R. A. (2014). The Biology of Cancer. United Kingdom: Garland Science.
5. The Molecular Biology of Cancer. (2009). Germany: Wiley.
6. Punt, J., Stranford, S., Jones, P., Owen, J. (2018). Loose-leaf Version for Kuby Immunology. United States: W. H. Freeman.
7. Male, D. K. (2013). Immunology. Netherlands: Elsevier/Saunders.
8. Owen, J. A., Punt, J., Stranford, S. A., and Jones, P. P. (2013). *Kuby immunology* (Vol. 27). New York: WH Freeman.

| **Semester III Paper II (Elective) Practical** | | | |
|---|---|---|---|
| **Course Code** | **Course Title** | **Hr** | **Cr** |
| **SIPBOELP612** | **Cytogenetics** | **2** | **1** |

**LEARNING OBJECTIVES:**

1. Blood group testing will help students to analyse the blood group and will get an insight of the immunological compatibility of various blood groups.
2. The study of the mitotic index will enable students to understand the process of mitosis and determine the rate of cell division.
3. The course would help students to identify various genetic diseases by chemical tests and karyotypes.
4. It will enable students to determine the mode of inheritance of genetic disease or trait.
5. The course will enable students to learn the technique of differential leukocyte count.

**COURSE OUTCOMES:**

After completion of the course, the learners would be able to:
**CO1:** Determine the blood group.
**CO2:** Study mitotic index of plant sample.
**CO3:** Review genetic diseases by chemical tests and karyotypes of genetic disorders.
**CO4:** Solve problems-based pedigree analysis of genetic diseases.
**CO5:** Identify and count different types of leukocytes.

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|---|---|
| 1. | Determine of blood group of the blood sample by the slide agglutination test. |
| 2. | Study of mitotic index. |
| 3. | Identification of genetic diseases by chemical tests. |
| 4. | Study of karyotypes of genetic disorders. |
| 5. | Problems based on genetic diseases (pedigree analysis). |
| 6. | Determination of differential leukocyte count. |

| 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.)

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| Semester IV Paper I (Core) | | | |
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| **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.

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| **UNIT I – Gene Regulation in Bacteria and Bacteriophage** | **15** | **1** |

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| 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:**


1. Willey, J. M. (2020). Prescott's Microbiology. United Kingdom: McGraw-Hill Education.
2. Paro, R., Grossniklaus, U., Santoro, R., and Wutz, A. (2021). *Introduction to epigenetics* (p. 215). Springer Nature.
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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.

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| 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 II (Elective)** | | | |
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| **Course Code** | **Course Title** | **Hr** | **Cr** |
| **SIPBOEL622** | **Plant Breeding** | **45** | **3** |

**LEARNING OBJECTIVES:**

The elective course Plant Breeding in Semester IV includes units on plant breeding, plant genetic engineering and molecular plant breeding (transgenic crops). The course aims to explore the objectives of plant breeding and different methods of plant improvement. It will make students understand various methods of production of transgenic plants. The course will enable students to study molecular markers with their applications in plant breeding.

**COURSE OUTCOMES:**

After completion of the course, the learners would be able to:
**CO1:** Explain the aims and objectives of plant breeding, including steps of plant introduction and acclimatization; compare selection methods in self-pollinated and clonal crops, describe hybridization techniques, and summarize aspects of distant hybridization along with their applications in crop improvement.
**CO2:** Employ the knowledge about natural and artificial methods of gene transfer and selectable markers to produce transgenic plants.
**CO3:** Review the production of biotic and abiotic stress-resistant transgenic plants and plant-based pharmaceuticals, and discuss the associated risks of genetically engineered plants.

| **UNIT I – Plant Breeding** | | **15** | **1** |
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| 1. | Aims and objectives, plant introductions, and acclimatization.<br>Selection – Mass, pure line, and clonal. | | |

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| | Hybridization in self-pollinated and cross-pollinated plants.<br>Male sterility. | | |
| 2. | Distant hybridization: In nature (plant breeding) – Barriers to the production of distant hybrids; Unreduced gametes in distant hybridization.<br>Applications of distant hybridization in crop improvement; Limitations of distant hybrids. | | |
| **UNIT II – Plant Genetic Engineering** | | **15** | **1** |
| 1. | Introduction; Natural method of gene transfer (*Agrobacterium* and virus) | | |
| 2. | Artificial methods of gene transfer:<br>Chemical methods: DEAE-Dextran (Diethylaminoethyl Dextran) mediated DNA transfer, Lipofection, Calcium phosphate, Direct DNA uptake by protoplast.<br>Physical methods: Electroporation, particle gun transformation, Sonoporation. | | |
| 3. | Selectable markers | | |
| 4. | Risk and Controversies: Concerns about human health, damage to the environment, and damage to current farming practices. | | |
| **UNIT III – Molecular Plant Breeding (Transgenic Crops)** | | **15** | **1** |
| 1. | Introduction | | |
| 2. | DNA-based molecular marker aided breeding: RFLP; RAPD; AFLP; STS-Microsatellites, SCAR, ISSR, CAPS; SNP Marker system selection. | | |
| 3. | Production of biopharmaceuticals in transgenic plants. | | |
| 4. | Edible vaccines and Plantibodies. | | |
| 5. | Production of Transgenic plants: virus-resistant and herbicide-resistant plants; drought resistant plants; Bt-Cotton, Golden rice. | | |

**References:**


1. Dubey R.C. (2005), A Textbook of Biotechnology, S.Chand and Co. Publ.
2. Goodsell D. (2004), Biotechnology Lessons from Nature, John Wiley and Sons Inc. Publ.
3. Satyanarayana, U. (2017). Biotechnology. India: Books and Allied (p) Limited.
4. Singh, B. D. (2009). Plant Breeding: Principles and Methods. India: Kalyani Publishers.
5. Singh, B. D., and Shekhawat, N. S. (2017). Molecular Plant Breeding. Scientific Publishers.
6. Singh, B. D. Biotechnology. India: Kalyani Publishers.
7. Glick, B. R., and Patten, C. L. (2022). *Molecular biotechnology: principles and applications of recombinant DNA*. John Wiley and Sons.


| **Semester IV Paper II (Elective) Practical** | | | |
|---|---|---|---|
| **Course Code** | **Course Title** | **Hr** | **Cr** |
| **SIPBOELP622** | **Plant Breeding** | **2** | **1** |

**LEARNING OBJECTIVES:**

1. The course will enable students to identify mutant genotype in *Drosophila*.
2. It will give hands-on training to culture *Drosophila* and use it as a model organism for the study of genetic traits.

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| 3. The course will aid students to estimate the pollen fertility in locally grown plants and to learn various kinds of emasculation. |
| **COURSE OUTCOMES:**<br><br>After completion of the course, the learners would be able to:<br>**CO1:** Culture *Drosophila*, study its genetic traits and identify mutant genotype in *Drosophila*.<br>**CO2:** Predict genotype and allele frequencies in future generations using Hardy Weinberg law.<br>**CO3:** Estimate pollen fertility locally grown plants.<br>**CO4:** Explain and compare effects of mutagens used for crop improvement.<br>**CO5:** Explain and perform emasculation for controlled pollination. |

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| 1. | Identification of mutant genotype in *Drosophila*. |
| 2. | Culturing of *Drosophila* and study of genetic traits. |
| 3. | Problems based on Hardy Weinberg law. |
| 4. | Estimation of pollen fertility in locally grown plants. |
| 5. | Mutation breeding. |
| 6. | Emasculation - kinds of emasculation. |

| **Semester IV** | | | |
|---|---|---|---|
| **Course Code** | **Course Title** | **Hr** | **Cr** |
| **SIPBORP621** | **Research Project** | **12** | **6** |
| **LEARNING OBJECTIVES:**<br><br>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:**<br><br>After completion of the course, the learners would be able to:<br>**CO1:** Contribute to current research and development work and also gain deeper insight into it.<br>**CO2:** Acquire and display the knowledge and skills required for independent work as a Master of Science in Botany.<br>**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.) | | | |