UNIVERSITY OF DELHI

MASTER OF SCIENCE
(TWO-YEAR PROGRAMME)
IN
PLANT MOLECULAR BIOLOGY AND BIOTECHNOLOGY
(Effective from the Academic Year 2025-2026)

BROCHURE

Department of Plant Molecular Biology
Faculty of Interdisciplinary and Applied Sciences
University of Delhi, South Campus
New Delhi – 110 021, India

NEP 2020 based syllabus as approved in the meeting of 'Committee of Courses' held on ________in the meeting of 'Faculty of Interdisciplinary and Applied Sciences' held on ___________, and meeting of 'Standing Committee' held on_____________

Revised Syllabus as approved by Academic Council on _____, 2025
and
Executive Council on _____, 2025

Contents

I. About the Department

The **Department of Plant Molecular Biology,** established in 1988 under the Faculty of Interdisciplinary and Applied Sciences, advances research and education in frontier areas of plant molecular biology and biotechnology. It was enriched by the merger of the **Unit for Plant Cell and Molecular Biology** in 1988 (originally established by the DST) and the award of 'Committee on Strengthening of Infrastructure for Science and Technology (COSIST)' grant by the UGC (1990–1995). The Department was recognized under UGC's Special Assistance Programme (DRS Phase I-III, 2002-2018) to strengthen research and teaching in Functional Genomics. Since its inception, the Department has been led by eminent scientists, including Prof. S.C. Maheshwari (1988–1992), Prof. Akhilesh K. Tyagi (1988, 1992–95, 1998–2001), Prof. Jitendra P. Khurana (1995–1998, 2001–2004, 2014–2016), Prof. Paramjit Khurana (2004–2007, 2016–19), Prof. Anil Grover (2007–2010, 2019–22), Prof. Indranil Dasgupta (2010–2013), Prof. Madan Mohan (2013–2014), and Prof. Sanjay Kapoor (current Head, since 2022).

We are one of India's top-ranking institutions for Plant Science Education and Research, nestled within the secure and picturesque South Campus of the University of Delhi. With Delhi University's rich legacy of academic and research excellence, the Department of Plant Molecular Biology is committed to upholding and advancing this tradition through its innovative teaching and cutting-edge research programmes. Since its establishment, DPMB has been at the forefront of numerous multinational research initiatives, fostering a dynamic and globally connected research community, notably those funded by the Rockefeller Rice Biotechnology Program (1990-2000), which bolstered expertise in transgenics and analysis of genes. With the turn of the millennium, the Department played a pivotal role in large-scale genome sequencing, contributing to the complete sequencing of the rice genome (2005), tomato genome (2012), and wheat genome (2019) as part of several international consortia. Our faculty maintains strong collaborations with leading international researchers through bilateral research programmes, providing young scientists with unparalleled opportunities to engage in world-class research and turn their aspirations into reality.

Faculty members have undertaken several research initiatives supported by major grants from DBT, DST, UGC, the European Commission, and the Rockefeller Foundation (in the area of the Centre for Plant Molecular Biology, Genome Sequencing Initiatives, and Functional Genomics). Faculty members actively participate in multi-institutional and international collaborations, producing 900+ publications in high-impact journals such as *Nature, Genome Research, Nucleic Acids Research, Trends in Biotechnology, Trends in Plant Science, Plant Journal, Plant Physiology, Plant Biotechnology Journal, New Phytologist, Journal of Experimental Botany, Plant Cell & Environment, and Bioessays,* along with several patents.

Their contributions have been recognized through national and international fellowships and awards.

While emphasizing fundamental research and training, the Department is committed to translational applications for human welfare. Its alumni hold key positions in academia and research institutions in the country and worldwide, including Washington State University; University of Nebraska, Lincoln; Texas Tech University Health Sciences Centre Rothamsted Research Station), Guru Jambheshwar University (Hisar), Bioseed Research (Hyderabad), ICAR-IARI, ICGEB, BRIC-NIPGR, JNU, IIT Delhi, BRIC-NII, Indraprastha University, IISER (Bhopal), TERI University, CIMAP (Lucknow), Birsa Agricultural University (Ranchi) and Assam Agricultural University (Jorhat), BITS (Hyderabad), NABI (Mohali), University of Hyderabad, among others. Many lead research groups in both academia and industry, contributing significantly to the advancement of plant molecular biology.

II. Introduction to NEP Programme

Scope

The National Education Policy (NEP) 2020 aims to transform post-graduate education by introducing flexibility, interdisciplinary, and skill-oriented learning. The program is structured to equip students with advanced knowledge and specialized skills, preparing them for research and innovation. The key features of this program include flexible program structure, interdisciplinary learning, multiple entry and exit points, credit mobility, focus on emerging fields, skill-based learning, continuous assessment, and emphasis on research and skill development. NEP2020 modernizes post-graduate education by making it flexible, industry-aligned, and student-centric, empowering learners to shape their academic journey in line with their interests and career aspirations.

Definition of Keywords

i. **"Discipline Specific Core (DSC)"** means a course that a student admitted to a particular programme must successfully complete to receive the degree and which cannot be substituted by any other course. DSCs shall be the core credit courses of that particular discipline which will be appropriately graded and arranged across the semesters of study, being undertaken by the student, with multiple exit options as per NEP 2020.

ii. **"Discipline Specific Elective (DSE)"** shall be a pool of credit courses of that particular discipline (single discipline programme of study) or those disciplines (multidisciplinary programme of study), as the case may be, which a student chooses to study from his/her particular discipline(s). This course is to be selected by a student out of such courses offered in the same or any other Department/Centre of FIAS.

iii. **"Generic Electives (GEs)"** are a pool of courses which is meant to provide multidisciplinary or interdisciplinary education to students**.** various disciplines of study (excluding the GEs offered by the parent discipline), in groups of odd and even semesters, from which a student can choose. The concerned Department would identify the GEs specified in the framework as GEs to be taught in a Programme.

iv. **"Skill Enhancement Courses** (**SEC)"** are skill-based courses in all disciplines aimed at providing students with hands-on training, competencies, proficiency and skills. SEC courses may be chosen from a pool of courses designed to provide skill-based instruction.

v. **"Dissertation"** means a research project completed and written as part of a postgraduate degree

vi. **"Credit"** is a unit by which the coursework is measured. It determines the number of hours of instructions required per week. One credit is equivalent to one hour of teaching (lecture or tutorial) or two hours of practical work/field work per week.

vii. **"SGPA"** is the Semester Grade Point Average calculated for individual semesters.

viii. **"CGPA"** is the Cumulative Grade Point Average calculated for all courses completed by the students at any time. CGPA is calculated each year for both semesters clubbed together.

ix. **"Grand CGPA"** is calculated in the last year of the course by clubbing together CGPA of two years, i.e., four semesters. Grand CGPA is given in the transcript form. To benefit the student a formula for conversion of Grand CGPA into %age marks is given in the Transcript.

III. M.Sc. PMBB Programme Details

The **M.Sc. Programme in Plant Molecular Biology and Biotechnology (PMBB)** at the Department of Plant Molecular Biology Department (PMB), University of Delhi South Campus (UDSC), offers an enriching and dynamic learning experience at the forefront of modern Plant Sciences. Designed to keep pace with cutting-edge advancements, this program equips students with the expertise needed for a potential career in Plant Molecular Biology and allied fields. With a meticulously structured curriculum, the PMBB program nurtures futureready researchers and skilled professionals, bridging the gap between academia and industry. Graduates of this program are well-positioned to contribute to leading research institutions and drive innovation in the rapidly growing Plant Biotechnology sector, both in India and abroad.

Our comprehensive curriculum encompasses Classroom Teaching, Laboratory Practical sessions, Tutorials in the form of Seminars, and an invigorating Dissertation component. Throughout the course, students will explore courses on Discipline Specific Core, Discipline Specific Elective, Generic Elective, Advanced Research Methodology /Tools for Research, Techniques of Research Writing and Skill-based papers intelligently distributed across four Semesters. These courses will be taught within the PMB Department, while the students will have the opportunity to choose from a diverse array of topics offered by sister Departments within the Faculty of Interdisciplinary and Applied Sciences (FIAS) at UDSC for the remaining paper(s).

The journey begins in the **first semester** with three core Papers from the PMB Department, delving into the Basics of Genetics and Molecular Biology, Molecular Cell Biology, and Recombinant DNA technology. Additionally, the course also offers three elective courses focusing on advanced subjects: Model Organisms in Molecular Biology Research, Plants in Human Health and Nutrition, and Laboratory Instrumentation & Safety. Students have a choice to select any two of the three DSE papers offered, or they can also select one of the DSE offered by PMB and any one Generic Elective (GE) paper offered by other departments of FIAS. The students will also be introduced to Biological Data Analysis and Interpretation as their SEC paper in the first semester itself. Notably, a paper on Model Organisms in Molecular Biology Research is open to students from other FIAS Departments too, adding to the interdisciplinary learning experience. The DSEs, Biological Data Analysis and Interpretation, and SEC papers provide an opportunity to delve deeper into specialized areas and expand the knowledge base.

In the **second semester**, students will dive into three captivating DSC Papers exploring the Molecular Basis of Plant Development, Plant Biochemistry and Metabolism, Eukaryotic Gene expression and regulation and either any two of the DSE papers offered (Proteomics, and Metabolomics, Cell Signaling, Plant-Environment Interaction) or one DSE offered by PMB and one GE offered by other departments of FIAS. Notably, a paper on Proteomics and Metabolomics is also open to students from other FIAS Departments.

The **third semester** brings an advanced DSE Paper to the forefront, Plant Molecular Biology and Biotechnology, and two DSE papers, Crop Biotechnology and Advanced Plant Imaging. Moreover, students will get an opportunity to learn the skills of Bioinformatics as they will be taught two skill-based courses in the same semester: Computational Biology - I and Bioinformatics.

In the **final semester**, the PMB department offers two DSE papers: Data Analytics and Biocuration, Epigenetics and Small RNA Biology, and a two-credit course on Science communication and presentation. Complementing all the DSC papers and most of the DSE papers, hands-on Practical sessions are thoughtfully designed to provide students with real-world experience, while Tutorials empower students to sharpen their presentation skills. The third and fourth semesters will focus on applying the ideas more practically and hands-on, especially through dissertations. This can be an exciting time to really dive deep into students' areas of interest and put theory into practice, which will embark on an immersive research journey under the guidance of esteemed faculty members. This experience will equip you with invaluable skills and direct exposure to conducting cutting-edge research in a modern laboratory environment.

PMBB Programme Details

i. **Programme Objectives (POs):** The M.Sc. Course in Plant Molecular Biology and Biotechnology at the Department of Plant Molecular Biology (PMB), UDSC, has been designed to provide students with comprehensive exposure to the latest advancements in the exciting and burgeoning areas of modern Plant Sciences. This program equips students with the necessary theoretical knowledge and practical skills to pursue cutting-edge research in Plant Molecular Biology and related disciplines. Additionally, it aims to develop a skilled workforce capable of contributing to the rapidly growing Plant Biotechnology industry, opening avenues for careers in academia and industry.

ii. **Programme Specific Outcomes (PSOs):** After successfully completing the program, students will have developed a comprehensive and in-depth understanding of plant systems at the molecular level. They will gain a clear and precise grasp of how plants respond at the molecular level to various environmental and developmental cues. In addition to building a strong theoretical foundation, students will acquire essential practical skills, encompassing both wet-lab techniques and computational analyses. This well-rounded training will equip them with the expertise necessary to undertake challenging research projects in their future careers. Furthermore, they will gain insights into the complexities of molecular engineering and its applications in developing improved crop varieties. The program is designed to equip students with the knowledge and skills required to meet the criteria for conducting research in line with the BioE3 (Biotechnology for Economy, Environment, and Employment) Policy of the Government of India. By integrating advanced biotechnological approaches with principles of environmental sustainability, students will be prepared to contribute to innovative solutions that address the growing global demand for food and agricultural resilience.

iii. **Programme Structure**: The M.Sc. in Plant Molecular Biology and Biotechnology (PMBB) is a one/or two-year programme offering a comprehensive and structured curriculum designed to provide both fundamental knowledge and advanced expertise in the field. The program includes:

- **DSCs (4 credits each)** establish a strong foundation, ensuring students gain up-to-date concepts in plant molecular biology and biotechnology.
- **DSEs discipline or internal elective papers (4 credits each)** offer advanced and in-depth exploration of specific topics that build upon concepts introduced in the core papers. These electives also incorporate substantial hands-on training to enhance practical understanding and research skills.
- **GEs (4 credits)** are designed to provide specialized knowledge and practical insights in an emerging area of biological sciences, accessible to a broader cohort of life sciences students.
- **SECs (2 credits each)** are tailored to provide practical, industry-relevant, and research-driven skills that prepare students for both academia and industry.
- **Three papers of 2 credits each** focus on the advanced research methods of the core discipline, basic and advanced research tools, and research writing techniques.
- **A dissertation (12/26 credits)** is structured to engage students in independent research, develop problem-solving skills, and contribute to scientific advancements in the field.

The well-balanced curriculum ensures that graduates acquire both theoretical expertise and practical proficiency, equipping them for careers in academic research, biotechnology industries, and related scientific fields.

Semester-wise Programme Structure

The M.Sc. The Plant Molecular Biology and Biotechnology program is a two-year course divided into four semesters. A student is required to complete eighty-eight credits to complete the course and be awarded a degree. A student has to accumulate twenty-two credits in each of the four semesters. The program structure is based on the Post Graduate Curricular Framework under NEP-2020. Under PGCF-NEP2020, in the first year of the program, the student is required to study mandatory Discipline Specific Core courses (three DSCs in each semester) and a total of four Discipline Specific Elective courses (two DSEs in each Semester). In lieu of one DSE in each Semester, the student may choose to study a General Elective course offered by any other Department of FIAS. In addition, the student will also be required to study one mandatory skill-based practical course (SBC) each semester of the first year. In the second year of the program, the student will have an option to choose any one of the three structures, which are: Structure 1 (PG with only coursework), Structure 2 (PG with coursework and research), or Structure 3 (PG with research). The details regarding these structures have been summarized in tabular form.

Course Credit Scheme

Two-Year PG Course Credit Scheme

Structure-1 (Level 6.5): (PG with only coursework)

Semester	Core Courses		Elective courses		Skill-based course/ Hands on Learning		Research Methods/ Tools/ Writing		Dissertation/ Project		Total Credits
	No. of courses	Total credits	No. of courses	Total credits	No. of courses	Total credits	No. of courses	Total credits	No. of courses	Total credits	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	2	8	3	12	1	2	-	-	-	-	22
IV	2	8	3	12	1	2	-	-	-	-	22
Total Credits	**40**		**40**		**8**		**-**		**-**		**88**

Structure-2 (Level 6.5): (PG with coursework and research)

Semester	Core Courses		Elective courses		Skill-based course/ Hands on Learning		Research Methods/ Tools/ Writing		Dissertation/ Project		Total Credits
	No. of courses	Total credits	No. of courses	Total credits	No. of courses	Total credits	No. of courses	Total credits	No. of courses	Total credits	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	2	8	2	8	-	-	-	-	1	6	22
IV	2	8	2	8	-	-	-	-	1	6	22
Total Credits	**40**		**32**		**4**		**-**		**12**		**88**

Structure-3 (Level 6.5): (PG with research)

Semester	Core Courses		Elective courses		Skill-based course/ Hands on Learning		Research Methods/ Tools/ Writing		Dissertation/ Project		Total Credits
	No. of courses	Total credits	No. of courses	Total credits	No. of courses	Total credits	No. of courses	Total credits	No. of courses	Total credits	
I	3	12	2	8	1	2	-	-	-	-	22
II	3	12	2	8	1	2	-	-	-	-	22
III	1	4	1	4	-	-	2	4	1	10	22
IV	-	-	1	4	-	-	1	2	1	16	22
Total Credits	**26**		**24**		**4**		**6**		**26**		**88**

SEMESTER-WISE PROGRAMME STRUCTURE

First-Year Course Details (Common in Structure 1, 2, and 3)

PART- I	Semester 1			
Name of the Course	**Credits in Each Course**			
	Theory	**Practical**	**Tutorial**	**Total Credits**
DISCIPLINE SPECIFIC CORE COURSES (DSC)				
PBSC101: Basic Molecular Biology and Genetics	3	1	0	4
PBSC102: Molecular Cell Biology	3	1	0	4
PBSC103: Recombinant DNA technology-Concepts, Techniques, and Applications	3	1	0	4
DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)*				
PBSE104: Plants in Human Health and Nutrition	3	1	0	4
PBSE105: Laboratory Instrumentation & Safety	3	1	0	4
GENERIC ELECTIVE COURSE (GE)*				
PBGE106: Model Organisms in Molecular Biology Research	3	0	1	4
SKILL DEVELOPMENT COURSE				
PBSD107: Biological Data Analysis and Interpretation	1	1	0	2
TOTAL CREDITS IN SEMESTER 1				**22**

**A student may opt for either two DSE, or one DSE with one GE*

PART-I	Semester 2			
Name of the Course	**Credits in Each Course**			
	Theory	**Practical**	**Tutorial**	**Total Credits**
DISCIPLINE SPECIFIC CORE COURSES (DSC)				
PBSC201: Molecular Basis of Plant Development	3	1	0	4
PBSC202: Plant Biochemistry and Metabolism	3	1	0	4
PBSC203: Eukaryotic Gene expression and regulation	3	1	0	4
DISCIPLINE SPECIFIC ELECTIVE COURSES (DSE)*				
PBSE204: Cell Signalling and Communication	3	1	0	4
PBSE205: Plant-Environment Interaction	3	1	0	4
GENERIC ELECTIVE COURSE (GE)*				
PBGE206: Proteomics, Metabolomics & Elementomics	3	0	1	4
SKILL DEVELOPMENT COURSE				
PBSD207: Plant Tissue Culture and Transformation Methodologies	0	2	0	2
TOTAL CREDITS IN SEMESTER 2				**22**

**A student may opt for either two DSE, or one DSE with one GE*

Second Year: Structure - 1 (PG with only coursework)

Semester-3

	Credits in each course			
Course	Theory	Practical	Tutorial	**Credits**
Discipline Specific Core (DSC) courses				
	3	1	0	4
	3	1	0	4
Discipline Specific Elective (DSE) courses*				
	3	1	0	4
	3	1	0	4
	3	1	0	4
Generic Elective (GE) course*				
	3	0	1	4
Skill-based course/ workshop/ Specialised laboratory/ Hands on Learning				
	0	2	0	2
Total credits			0	**22**

*(*a student can opt for either three DSE course, or two DSE with one GE*)

Semester-4

	Credits in each course			
Course	Theory	Practical	Tutorial	**Credits**
Discipline Specific Core (DSC) courses				
	3	1	0	4
	3	1	0	4
Discipline Specific Elective (DSE) courses*				
	3	1	0	4
	3	1	0	4
	3	1	0	4
Generic Elective (GE) course*				
	3	0	1	4
Skill-based course/ workshop/ Specialised laboratory/ Hands on Learning				
	0	2	0	2
Total credits				**22**

*(a student can opt for either three DSE course, or two DSE with one GE)

Second Year: Structure - 2 (PG with Coursework and Research)

Semester-3

	Credits in each course			
Course	Theory	Practical	Tutorial	**Credits**
Discipline Specific Core (DSC) courses				
	3	1	0	4
	3	1	0	4
Discipline Specific Elective (DSE) courses*				
	3	1	0	4
	3	1	0	4
Generic Elective (GE) course*				
	3	0	1	4
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
	0	6	0	6
Total credits				**22**

*(a student can opt for either two DSE courses, or one DSE and one GE)

Semester-4

	Credits in each course			
Course	Theory	Practical	Tutorial	**Credits**
Discipline Specific Core (DSC) courses				
	3	1	0	4
	3	1	0	4
Discipline Specific Elective (DSE) courses*				
	3	1	0	4
	3	1	0	4
Generic Elective (GE) course*				
	3	0	1	4
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
	0	6	0	6

Total credits				**22**

(a student can opt for either two DSE courses, or one DSE and one GE)

Second Year: Structure - 3 (PG with Research)

Semester-3

	Credits in each course			
Course	Theory	Practical	Tutorial	**Credits**
Discipline Specific Core (DSC) courses				
	3	1	0	4
Discipline Specific Elective (DSE) courses*				
	3	1	0	4
Research Methods/ Tools/ Writing				
	2	0	0	2
	2	0	0	2
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
	0	10	0	10
Total credits				**22**

Semester-4

	Credits in each course			
Course	Theory	Practical	Tutorial	**Credits**
Discipline Specific Elective (DSE) courses*				
	3	1	0	4
Research Methods/ Tools/ Writing				
	2	0	0	2
Dissertation/ Academic Project/ Entrepreneurship/ Intensive problem-based research				
	0	16	0	16
Total credits				**22**

iv. Eligibility for Admissions

- A 3-year/6-semester bachelor's degree with a minimum of 120 credits for a 2-year/4-semester PG programme at level 6.5 on the National Higher Education Qualifications Framework (NHEQF).
- A bachelor's degree with Honours/ Honours with Research with a minimum of 160 credits for a 1-year/2-semester PG programme at level 6.5 on the NHEQF.
- A student is eligible for admission in PMBB PG programs if the student qualifies for the CUET(PG) or GAT-B Entrance Examination.
- Appropriate relaxation for candidates belonging to reserved categories is applicable as per the university norms.

v. Assessment of Students' Performance and Scheme of Examination

- The examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

vi. Pass Percentage & Promotion Criteria

- As per the UGC / University Examination rule.

vii. Conversion of Marks into Grades

- As per the UGC / University Examination rule.

viii. Grade Points

- As per the UGC / University Examination rule.

ix. CGPA Calculation

- As per the UGC / University Examination rule.

x. SGPA calculation

- As per the UGC / University Examination rule.

xi. Grand SGPA calculation

- As per the UGC / University Examination rule.

xii. Conversion of Grand CGPA into marks

- As per the UGC / University Examination rul**es.**

xiii. Conversion of Grand CGPA into marks

- As per UGC / University Examination rule.

xiv. Division of Degree into Classes

- As per the UGC / University Examination rule.

xv. Attendance Requirement

- As per the UGC / University Examination rule.

xvi. Span Period

- As per the UGC / University Examination rule.

xvii. Attendance Requirement

- As per the UGC / University Examination rule.

IV. Course-wise Content Details for the PMBB Programme

SEMESTER 1

PBSC101: Basic Molecular Biology and Genetics

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSC101: Basic Molecular Biology and Genetics	4	3	0	1	B.Sc. in any branch of Science	NA

Learning Objectives

The course aims to deliver in-depth knowledge of genomic stability, DNA replication, transcription, translation, and gene regulation, using prokaryotic model systems to the students. This course will also provide a deep understanding of genetic principles, from Mendelian inheritance to modern molecular genetics. Students will explore gene interactions, linkage, mapping techniques, and quantitative genetics. Through theoretical knowledge and analytical techniques, students will develop experimental and analytical skills in genetics and molecular biology.

Learning Outcomes

Upon completion, students will understand DNA replication, transcription, and translation processes, as well as gene regulation models. Students will have a strong foundation in classical and molecular genetics, enabling them to analyze genetic inheritance, gene mapping, and genome stability mechanisms. Students will develop skills in applying genetic analysis tools and interpreting experimental data. Students will learn methods to estimate point mutation, homologous recombination, and transposition. Further, students will acquire skills in cytogenetic techniques for chromosome analysis.

Course Content (45 hours)

Unit 1: Mechanism of Replication in Prokaryotes -- DNA polymerases and accessory proteins; Proteins at the origin of replication and replication fork; Concept of replicon; Fidelity of replication; Control of replication of chromosomes and extrachromosomal elements. 6 hours

Unit 2: Prokaryotic Transcription, Translation and its Regulation -- Discovery of RNA; Initiation of transcription: Promoters and other control elements; RNA polymerases and accessory factors; Sigma factors and their interactions with promoters; Transcriptional controls; Concept of operons; Transcription termination; Rho factor and polar mutations; Gene regulation in Bacteriophages: lysogenic and lytic cycles, regulation of gene expression; Initiation, elongation, and termination of translation and the accessory proteins; Structural and functional studies on ribosomes: ribosomal RNAs and proteins; Mapping the decoding and peptidyl transferase sites of ribosome; Transfer RNAs and genetic code; Translational fidelity. 16 hours

Unit 3: Mendelian Principles, Gene Mapping and Quantitative Genetics -- Introduction to Mendelian Genetics; codominance, incomplete dominance, gene interactions (epistasis), pleiotropy, penetrance and expressivity, linkage and crossing over, sex linkage, genome imprinting; Genetic and physical maps; Molecular markers: RFLP, RAPD, AFLP, SSR, SNP; Mapping genes by interrupted mating, polygenic inheritance, QTL (Quantitative trait locus) mapping, LOD (Logarithm of the Odds) score for linkage testing, pedigree analysis, karyotypes, tetrad analysis, Chi-square test in linkage analysis. 15 hours

Unit 4: Maintenance of Genomic Flexibility and Integrity -- Spontaneous and induced mutations; Mutagens; Mechanisms of homologous and site-specific recombination (NHEJ, HR, MMEJ); Mechanism of meiotic crossing-over; DNA repair and retrieval systems; Transposons and retro-transposons. 8 hours

Practicals (30 hours)

1. Extraction and analysis of genomic DNA from bacteria.
2. To perform bacteriophage plaque assay.
3. Study of frameshift mutation and homologous recombination by histochemical assays.
4. Visualization of chromatin structure using DAPI staining.
5. Analysis of cell ploidy by chromosomal counting at metaphase/flow cytometry.

Suggested Readings:

1. Clarke, D. and Pazdernik, N. (2013) Molecular Biology. Academic Cell, USA. ISBN: 9780123785947.
2. Griffiths, A., Wessler, S., Lewontin, R. and Carroll, S. (2007) Introduction to Genetic Analysis. W. H. Freeman, USA. ISBN: 9780716768876.
3. Krebs, J. E., Goldstein, E. S. and Kilpatrick, S. T. (2013) Lewin's Genes XI. Jones and Bartlett Publishers, Inc., USA. ISBN: 9781284027211.
4. Tropp, B. E. (2014) Principles of Molecular Biology, Jones and Bartlett, USA. ISBN: 9781449689179.
5. Weaver, R. F. (2012) Molecular Biology. McGraw Hill, UK. ISBN: 9780073525327.

6. Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2017). Lewin's genes XII. Jones & Bartlett Learning. ISBN: 1284104494

SEMESTER 1

PBSC102: Molecular Cell Biology

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSC102: Molecular Cell Biology	4	3	0	1	B.Sc. in any branch of Science	NA

Learning Objectives

This paper is designed to provide an in-depth understanding of cell biology, focusing on the molecular and biochemical processes that regulate cellular functions. A key emphasis is placed on the molecular organization of biological macromolecules and their role in forming distinct subcellular structures, enabling the precise coordination of essential cellular processes.

Learning Outcomes

Students would learn about the structure-function relationship of cellular organelles from a molecular perspective, focusing on macromolecules at both cellular and subcellular levels. Students will explore key molecular, biochemical, and imaging techniques employed for studying cells and cellular processes. By integrating mechanistic insights, this course will equip students with the knowledge to design strategies for manipulating cellular processes to address challenges in managing nutrition and food security.

Course Content (45 hours)

Unit 1: Investigating the Cell and Cell wall -- Fundamentals of microscopy and imaging, techniques for analyzing the cell and its organelles; Cell wall composition and architecture, biogenesis and assembly, dynamic aspects of the cell wall during growth and differentiation.
9 hours

Unit 2: Membrane and Endomembrane Systems -- Structural models, composition and dynamics; Transport of ions and macromolecules: transporters and channels; Sensory physiology; Endo- and exo-cytosis; Membrane proteins and carbohydrates and their significance in cellular processes; Structure and function of Golgi apparatus, lysosomes and endoplasmic reticulum and microbodies; Intracellular membrane trafficking and vesicular transport; Membrane maturation and specialization: extracellular vesicles, multivesicular bodies**,** Kajal bodies, dicing bodies, and cytoplasmic bodies. 20 hours

Unit 3: Mitochondria, **Chloroplast and Nucleus** – Structure; Organization; Structure-function relationship; Import and export of molecules; Biogenesis, origin and evolution; Structure and function (architecture); Chromatin organization and packaging: heterochromatin, euchromatin, nucleosomes; Nuclear envelope and nuclear pore complex, Import and export of molecules.

12 hours

Unit 4: Cytoskeleton and Cellular Motility -- Organization and role of microtubules and microfilaments; Actin-binding proteins and their significance; Molecular motors; Intermediate filaments. 4 hours

Practicals (30 hours)

1. High-resolution imaging of epidermal peel cells of *Arabidopsis thaliana*/ *Nicotiana benthamiana* under confocal microscope.
2. Transient expression of fluorescent-tagged protein via Agrobacterium-based infiltration of leaf epidermal cells.
3. Monitor the localization of fluorescent-tagged protein at the subcellular level under a confocal microscope.
4. Preparation and visualization of leaf protoplasts of *Arabidopsis thaliana*/*Nicotiana benthamiana*.
5. To study the pollen viability and the effect of calcium on pollen germination.

Suggested Readings:

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P. (2015) Molecular Biology of the Cell. Garland Publishing, Taylor & Francis Group, USA. ISBN: 9781315735368.
2. Buchanan, B. B, Gruissem, W., Jones, R.L. (2015) Biochemistry and Molecular Biology of the Plants. American Society of Plant Physiologists, USA. ISBN: 9780470714218.
3. Karp, J. G. (2019). Cell and Molecular Biology. John Wiley & Sons, USA. ISBN: 9781119598169.
4. Kleinsmith, L. J. and Kish, V. M. (1996) Principles of Cell & Molecular Biology. HarperCollins College Publishers, USA. ISBN: 978-0065004045.
5. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretsher, A., Ploegh, H., Amon, A., Martin, K. (2016) Molecular Cell Biology. Freeman & Co., USA. ISBN: 978-1464183393.
6. Ruzin, S. E. (1999) Plant Microtechnique and Microscopy. Oxford University Press, USA. ISBN: 9780195089561.

Semester 1

PBSC103: Recombinant DNA Technology - Concepts, Techniques, and Applications

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSC103: Recombinant DNA Technology - Concepts, Techniques, and Applications	4	3	0	1	B.Sc. in any branch of Science	NA

Learning Objectives

The course is designed to provide a comprehensive understanding of the principles, methodologies, and tools in recombinant DNA technology. This will familiarize students with advanced techniques in molecular biology and equip them with hands-on knowledge about genetic engineering tools. Furthermore, they will learn about the applications of recombinant DNA technology in agriculture, medicine, and industry, while addressing ethical, social and regulatory concerns. The course will prepare students for research and innovation in emerging fields such as synthetic biology, metabolic engineering and genome editing. It will also provide a foundation to help students in developing advanced knowledge for succeeding semesters.

Learning Outcomes

The candidate will develop an in-depth knowledge of principles and applications of the instrumentation, basic and cutting-edge tools and techniques in recombinant DNA technology. Students will get acquainted with designing/conducting, and analyzing experiments and experimental data, respectively. Integration of theory and problem-solving exercises will motivate students to take a keen research interest and enhance their understanding of the topics they are taught. They will be able to evaluate the impact of recombinant DNA technology in agriculture, healthcare, and industry. The course will enable students to develop innovative solutions in genetic engineering, synthetic biology and protein engineering for real-world challenges.

Course Content (45 hours)

Unit 1: **Introduction to Recombinant DNA Technology** -- Historical perspectives and milestones; Basic principles and concepts; Methods of nucleic acids and protein analysis: Isolation and purification, electrophoresis techniques; Overview of genetic engineering tools. 6 hours

Unit 2: DNA Cloning Methodologies and PCR -- Key enzymes: restriction endonucleases, nucleic acid modifying enzymes; Advanced cloning methods: TA cloning, topoisomerase-based cloning, ligation-independent cloning, Gateway technology, Gibson cloning; Vectors for gene cloning: plasmids, phages, phagemids, cosmids, and other advanced vectors for cloning large DNA fragments; Methods for selection and screening of recombinant clones; Host systems: bacteria, yeast, and plant cells; Isolation of gene of interest: Direct selection, construction and screening of genomic and cDNA libraries, labelling and detection of nucleic acids, enriching clones by subtractive cloning and differential screening, differential display; Polymerase Chain Reaction (PCR) : concept and enzymes employed, optimization of PCR, types of PCR (touch-up, touch-down, hot-start, inverse, nested, gradient, Rapid Amplification of cDNA Ends (RACE), semi-quantitative and quantitative, Gene Splicing by Overlap Extension (gene SoEing), and applications of PCR; DNA sequencing methods. 15 hours

Unit 3: Methods to Study Gene Expression and Biomolecular Interactions and Protein Expression Systems -- Gene expression analyses at the transcriptional level (Northern blotting and its variants, real-time PCR, S1 nuclease mapping, *in situ* hybridization, RNase protection, nuclear run-on assays), translational level: Western blotting, Enzyme-Linked ImmunoSorbent Assay (ELISA) and immunofluorescence assays; DNA-protein: Electrophoretic Mobility Shift Assay (EMSA), DNase I footprinting, Chromatin ImmunoPrecipitation (ChIP), Yeast one-hybrid (Y1-H), RNA-protein: Y3-H, northwestern, RNA ImmunoPrecipitation (RIP); protein-protein interaction: Y2-H, pull down, Co-ImmunoPrecipitation (Co-IP), Fluorescence Resonance Energy Transfer (FRET), Bimolecular Fluorescence Complementation (BiFC); Protein Expression and Engineering: Tagging and overexpression of proteins in heterologous systems (*E. coli*, yeast, baculovirus, and mammals); Methods for mutagenesis of genes for obtaining altered proteins.

15 hours

Unit 4: Applications and Ethics of Recombinant DNA Technology -- Production of recombinant molecules for improving agronomic traits, diagnostic and therapeutic applications in human diseases; Impact and biosafety, moral, social, regulatory and ethical concerns; Future perspectives and emerging trends (introduction to gene editing, synthetic biology, and genome engineering, the role of artificial intelligence or AI, etc.) 9 hours

Practicals (30 hours)

1. Transformation of bacterial competent cells followed by blue-white screening for identification of recombinant plasmid.
2. Colony PCR for screening of recombinant plasmids.
3. Isolation of plasmid DNA from *E. coli* culture and quantitation of DNA.
4. Restriction digestion of plasmid DNA and resolution of the digested DNA by agarose gel electrophoresis.
5. Induction of protein expression in a heterologous bacterial system and analysis of the expressed protein using SDS-PAGE.

Suggested Readings:

1. Brown, T. A. (2020) Gene Cloning and DNA Analysis: An Introduction. 8th edition. Wiley-Blackwell Publishing, UK. ISBN: 9781119640783.
2. Brown, T.A. (2024) Genomes 5. 5th edition. CRC Press, India. ISBN: 9780367674076.
3. Dale J. W., Schantz M. V. and Plant N. (2011) From Genes to Genomes: Concepts and Applications of DNA Technology. 3rd edition. John Wiley & Sons, UK. ISBN: 9780470683859.
4. Glick B. R. and Patten C. L. (2022) Molecular Biotechnology: Principles and Applications of Recombinant DNA. 6Th edition. ASM Press, USA. ISBN: 9781683673668.
5. Watson, J.D, Caudy, A., Myers, R.M. and Witkowski, J. (2006) Recombinant DNA: Genes and Genomes. 3rd edition. W.H. Freeman & Co, India. ISBN: 9780716728665.
6. Green M. R. and Sambrook J. (2012) Molecular Cloning: A Laboratory Manual. 4th edition. CSHL Press, USA. ISBN: 9781936113422.
7. Primrose, S. B. and Twyman, R. M. (2006) Principles of Genetic Manipulation and Genomics. 7th edition. Blackwell Publishing, UK. ISBN: 9781405135443.

Semester 1

PBSE104: Plants in Human Health and Nutrition

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSE104: Plants in Human Health and Nutrition	4	3	0	1	B.Sc. in any branch of Science	NA

Learning Objectives

Plants play a crucial role in human health and nutrition by providing essential nutrients, bioactive compounds, and medicinal properties that support our well-being. The course aims to highlight the role of plants in human health and nutrition and explore the molecular basis of bioactive compounds in plants. The students will gain knowledge of plant-derived pharmaceuticals, nutraceuticals, and functional food. Furthermore, strategies for improving plant nutrition and ethical issues will be taught.

Learning Outcomes

The students will be able to understand the role of plants in human life, analyse functional foods and nutraceuticals. They will be able to comprehend the molecular basis of phytochemical synthesis and explore the plants as pharmaceuticals. Utilizing this knowledge, the students will be able to design innovative and novel strategies for plant biofortification and metabolic engineering to develop novel plant-based foods and sustainable nutritional and drug resources.

Course Content (45 hours)

Unit 1: Role of Plants in Human Health and Nutrition -- Plants in human health from biochemical perspective; History of plant-based nutrition and medicinal plants; Role of secondary metabolites in human health; Molecular basis of bioactive compounds and biosynthetic pathways.

10 hours

Unit 2: Plant-based Nutraceuticals and Medicine Systems -- Phytochemicals, Traditional and non-traditional nutraceuticals; Plant-derived probiotics and prebiotics; Biotechnological approaches for biofortification for enhanced nutrition; Plant-based Medicine Systems: Traditional knowledge and ethnobotany; Ayurvedic, Yoga, Unani, Siddha, and Homeopathic (AYUSH), other traditional systems; Modern systems of plant-based medicine and their importance in human health. 15 hours

Unit 3: Plants as Source of Pharmaceuticals -- Medicinal plants; Traditional plant-based formulations; Plant-derived molecules in drug development; Therapeutic use of poisonous plants; Pharmacogenomics; Ayurgenomics; Metabolic engineering for enhanced bioactive production; Good manufacturing practices (GMPs). 10 hours

Unit 4: Recent Advancements in Plant Science and Health – Plant vaccines; plant-focused biomanufacturing; DNA fingerprinting and barcoding of medicinal plants; synthetic biology for producing plant-derived therapeutic agents; plant-based meat alternatives and sustainable food sources; the role of microgreens and lower plants in nutrition; climate change and its impact on beneficial plant compounds; future perspectives and challenges; ethical and regulatory guidelines. 10 hours

Practicals (30 hours)

1. Pharmacognostic evaluation (macroscopic and microscopic) of medicinal plants.
2. Qualitative analysis of secondary metabolites: Alkaloids, Flavonoids, Tannins, Glycosides, Protein and Saponins, etc.
3. Quantitative analysis of secondary metabolites: Alkaloids, Phenolic Compounds, Flavonoids.
4. Perform chromatographic analysis of plant extracts.
5. Survey of medicinally important plants.

Suggested Readings:

1. Kumar, S., Dikshit, H.K., Mishra, G. P., Singh, A. (2022) Biofortification of staple crops. Springer NAture Singapore Pte Ltd. ISBN: 9789811632792.
2. Crozier, A., Clifford, M.N., Ashihara, H. (2006) Plant secondary metabolites: occurrence, structure and role in the human diet. Blackwell Publishing Ltd. ISBN: 9781405125093.
3. Simopoulos, A.P., Gopalan, C. (2003) Plants in Human Health and Nutrition Policy, Volume 91. ISBN: 3805575548.
4. The Ayurvedic Pharmacopoeia of India, Part I, Part II, Vol I- Vol III. Council for Research in Ayurvedic Sciences (*CCRAS).*
5. Database on Medicinal Plants used in Ayurveda and Siddha, Vol I- Vol VIII, Central Council for Research in Ayurvedic Sciences (*CCRAS).*
6. Chowdhury, S.R. (2023) Textbook of Food Science and Nutrition. Aaraban Publishers. ISBN:9789387270084.
7. Mudambi, R. S. and Rajagopal, M.V (1983) Foods and Nutrition. Wiley Eastern Ltd. Second Edition, New Delhi. ISBN: 9780852265833.

8. Keservani, R. K. (2024) Plant Metabolites and Vegetables as Nutraceuticals. Academic Press. ISBN: 9781774915448.
9. Usman, S., Budhrani N. (2020) Textbook of Plant Biotechnology. S Vikas and Company (PV).
10. Bharti, P. K. (2018) Nutraceuticals and Pharmaceutical from Medicinal Plants, Discovery Publishing House Pvt. Ltd. ISBN: 9789386841551.

Semester 1

PBSE105: Laboratory Instrumentation and Safety

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSE105: Laboratory Instrumentation and Safety	4	3	0	1	B.Sc. in any branch of Science	NA

Learning Objectives

The course aims to equip students with a comprehensive understanding of the essential laboratory instruments used in molecular biology, biotechnology, and related fields. It is designed to expose them to best practices and regulatory compliance necessary for maintaining a safe and efficient research environment.

Learning Outcomes

Students will understand the principles, operation, and applications of various laboratory instruments. They will develop proficiency in instrument calibration, maintenance, and troubleshooting to ensure accuracy and reliability in experimental outcomes. Students will gain hands-on experience with state-of-the-art laboratory equipment, preparing them for advanced research and industrial settings. They will also develop a strong understanding of laboratory best practices, including biosafety measures, waste disposal, and emergency response protocols.

Course Content (45 hours)

Unit 1: Introduction to Laboratory Safety and Waste Management -- Laboratory safety guidelines: safety rules, biosafety levels (BSL1-BSL4), handling biological specimens; Chemical, biological, and radiation safety: chemical and biological material labelling and inventory management; Chemical/non-chemical storage guidelines, transportation and usage precautions, chemical hazard and safety datasheets, safe handling of carcinogens, mutagens, and toxic chemicals, Compressed gas cylinders and liquid cryogen containers; Biosafety cabinets and laminar airflow systems; Emergency preparedness and waste management: fire hazards, first-aid procedures for chemical spillage and exposure; Hazardous waste minimization and accumulation rules; Disposal of infectious or biological waste, including GMOs (modified microbes, transgenic plants). 15 hours

Unit 2: Radiological Laboratories and Radiation Safety -- Nature of Radioactivity, biological effects of Ionizing Radiation, operational radiation exposure limits, radiation hazard evaluation and control, planning of radioisotope laboratories, regulatory aspects of radioisotope laboratories, disposal of radioactive waste. 8 hours

Unit 3: Essential Laboratory Instrumentation -- Operation, principles, calibrations, maintenance, and applications of general instruments: weighing balances, pH meter, autoclave, centrifuges, electrophoresis, spectrophotometers (UV-Vis and nanodrop), fluorometers, thermal cyclers (PCR, digital droplet PCR, and real-time PCR machines), incubators/shakers, chromatography, gel documentation system, phosphor imaging systems, Sanger sequencing instrumentation and techniques. 10 hours

Unit 4: Advanced Instrumentation in Plant Molecular Biology Research -- Electroporators**,** Surface Plasmon Resonance (SPR) Systems, Isothermal Titration Calorimeter, (ITC), BioLayer Interferometry (BLI), *in vivo* imaging system, phytotrons and greenhouses, photosynthesis measurement systems, Flow cytometry: fluidic system, optical system, signal detection and processing system, Fluorescent-Activated Cell Sorting (FACS); High-throughput plant phenomics systems, smart remote agriculture monitoring systems (Internet of Things or IoT-based monitoring, AI-based precision monitoring, data loggers). 12 hours

Practicals (30 hours)

1. Precision measurement and liquid handling using micropipettes.
2. Preparation of molecular biology reagents and buffers.
3. Colorimetric analysis of different biomolecules using spectrophotometer.
4. Differential centrifugation for separation of cell organelles.
5. Demonstration of Sanger sequencing technology and flow cytometry instrument.

Suggested Readings:

1. Brown, T.A. (2023). Essential Molecular Biology: A Practical Approach. ISBN: 9781383049282.
2. Wilson, K., Hofmann, A., Walker, J.M., & Clokie, S. (Eds.). (2018). Wilson and Walker's principles and techniques of biochemistry and molecular biology. Cambridge University Press. ISBN: 9781316677056, DOI: 10.1017/9781316677056.
3. Green M. R. and Sambrook J. (2012) Molecular Cloning: A Laboratory Manual. 4th edition. CSHL Press, USA. ISBN: 9781936113422.
4. McKinnon, K.M. (2018). Flow cytometry: an overview. Current protocols in immunology, 120(1), 5-1. doi.org/10.1002/cpim.40.

5. Doležel, J., Greilhuber, J., & Suda, J. (2007). Estimation of nuclear DNA content in plants using flow cytometry. Nature Protocols, 2(9), 2233-2244. doi.org/10.1038/nprot.2007.310.

Semester 1

PBGE106: Model Organisms in Molecular Biology Research

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBGE106: Model Organisms in Molecular Biology Research	4	3	1	0	B.Sc. in any branch of Science	NA

Learning Objectives

Model organisms have a pivotal role in advancing our understanding of fundamental biological processes. The course aims to provide an in-depth understanding of the significance of model organisms in molecular biology research. It will familiarize students with the criteria for selecting model organisms and the diversity of models used across different biological kingdoms. It will provide an opportunity to examine the unique features, advantages, and limitations of various model systems. Information will be imparted on emerging model organisms and non-model organisms with unique features and cutting-edge advancements such as artificial cell models. Ethical considerations will be discussed to ensure responsible research practices.

Learning Outcomes

Students will be able to understand the importance of model organisms and their contribution to molecular biology research in different fields. They will be able to evaluate and select appropriate model systems for specific research objectives and explore the utility of emerging model systems and novel technologies in advancing molecular biology research. Students will be aware of ethical issues and guidelines for humane and sustainable research involving model organisms.

Course Content (45 hours)

Unit 1: Introduction to Model organisms -- Fundamental concepts and importance of model organisms in molecular biology research, criteria for selecting model organisms, types of model organisms across different phyla, historical milestones, comparative overview between prokaryotic and eukaryotic model systems; Nobel prize-winning discoveries utilizing model organisms. 7 hours

Unit 2: Prokaryotic and Lower Eukaryotes Models -- Importance and utility of prokaryotic models and their genetic manipulation (e.g. *Escherichia coli, Bacillus subtilis, etc.*); Bacteriophages; Lower eukaryotes: Importance and utility of unicellular eukaryotes and their genetic manipulation; yeast (*Saccharomyces cerevisiae*, *Schizosaccharomyces pombe*); *Neurospora crassa*; *Dictyostelium discoideum.* 15 hours

Unit 3: **Animal and Plant Models** -- Importance and utility of animal models and their genetic manipulation, Vertebrates (*Mus musculus, Rattus norvegicus, Danio rerio, Xenopus laevis, Macaca* spp. and other primates), Invertebrates (*Drosophila melanogaster, Caenorhabditis elegans*), cell lines as *in vitro* models, human disease models; Plant Models: Importance and utility of plant models and their genetic manipulation, lower plants (microalgae for biofuels: *Chlorella vulgaris*, *Botryococcus braunii*, *Chlamydomonas reinharditii*, *Marchantia*, *Physcomitrella*); Monocots (*Oryza sativa*, *Brachypodium distachyon, Panicum spp.,* other models); Dicots (*Arabidopsis thaliana*, *Medicago truncatula*, *Jatropha curcas*, and other models). 15 hours

Unit 4: Emerging Model Organisms and Ethics -- Non-model species with unique features, such as Tardigrades, Axolotls, *Octopus bimaculoides*; Advances in model research: development of artificial cell models, other pioneering studies for insights into untapped species and their potential applications; Ethical considerations: animal welfare, regulatory guidelines, ethical issues, alternatives to animal models (such as organoids, *in silico* simulations, and integration of AI and computational models). 8 hours

Tutorials (15 hours)

Suggested Readings:

1. Ankey, R.A. and Leonelli S. (2021) Model organisms. Cambridge University Press. ISBN: 9781108742320.
2. Emerging model organisms: A Laboratory Manual Vol 1 (2009) Cold Spring Harbor Laboratory Press. ISBN: 978-0879698720.
3. Jarret, R.L and McCluskey, K. (2020) Biological resources of model organisms. 1st edition CRC Press. ISBN: 9781138294615.
4. Davis, R H. (2003) The Microbial Models of Molecular Biology: From Genes to Genome. OUP Oxford Press. ISBN: 9780195154368.
5. Tang B, Wang Y, Zhu J, Zhao W. (2015) Web resources for model organism studies. Genomics Proteomics Bioinformatics. 13(1), 64-68. DOI: 10.1016/j.gpb.2015.01.003.
6. Latest research and review articles from Scientific journals and book chapters.

Semester 1

PBSD107: Biological Data Analysis and Interpretation

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSD107: Biological Data Analysis and Interpretation	2	1	0	1	B.Sc. in any branch of Science	NA

Learning Objectives

This course provides an in-depth understanding of the fundamental and advanced research methodologies employed in plant molecular biology and biotechnology. It focuses on experimental design, data analysis, and scientific communication while integrating guest lectures of specialists (if required). Special emphasis will be given to high-throughput sequencing, genome editing, plant transformation techniques, and bioinformatics approaches relevant to molecular plant sciences.

Learning Outcomes

Upon completion of this course, students will be adept at designing robust biological experiments, performing comprehensive statistical analyses, and interpreting various data types with scientific rigor. They will gain proficiency in hypothesis testing, regression models, and survival analysis while understanding ethical concerns in biostatistics. Learners will acquire knowledge to analyze transcriptomic data using tools like DESeq2 and DAVID. Additionally, they will develop the ability to create effective, publication-quality visualizations of complex biological datasets.

Course Content

(Lectures combined with problem-solving practical sessions; 15+30 = 45 hours)

Unit 1: Experimental Design and Biostatistics -- Principles of experimental design; control groups, replication, and randomization; types of biological data and measurement scales; descriptive statistics (mean, median, variance, standard deviation); probability distributions (normal, binomial, Poisson); hypothesis testing (t-tests, chi-square, ANOVA, non-parametric tests); power analysis and sample size determination; ethical considerations in biostatistics;

6 hours

Unit 2: Gene expression analysis and Data Visualization -- Overview of transcriptomics; RNA sequencing (RNA-Seq), microarrays; data preprocessing (quality control, normalization, transformation); differential gene expression analysis; functional enrichment, pathway analysis; visualization techniques (heatmaps, volcano plots, expression profiles); case studies; hands-on analysis using tools like DESeq2, edgeR, STRING, DAVID. Principles of effective data visualization; types of visualizations (bar plots, scatter plots, box plots, heatmaps); visualization of complex biological data (networks, phylogenetic trees, multidimensional plots); best practices for scientific presentations and publications. 9 hours

Practicals (30 hours)

1. Design an experiment (e.g., drug effect on bacteria) and identify variables, control groups, and the method of randomization.
2. Analyze sample datasets (e.g., plant development-based measurements during stress responses); Classify data and discuss implications for statistical tests.
3. Run t-tests, chi-square tests, and ANOVA on the provided datasets.
4. Identify genes differentially expressed across conditions (using microarray or NGS datasets) and interpret results (using log2 fold changes, p-values, adjusted p-values).

Suggested Readings:

1. Quinn, G. P., & Keough, M. J. (2002). Experimental Design and Data Analysis for Biologists. Cambridge University Press. ISBN: 978-0521009768.
2. Heath, D. (1995). An Introduction to Experimental Design and Statistics for Biology. UCL Press. ISBN: 978-1857281323.
3. Welham, S. J., Gezan, S. A., Clark, S. J., & Mead, A. (2015). Statistical Methods in Biology: Design and Analysis of Experiments and Regression. CRC Press. ISBN: 978-1032918327.
4. Daniel, W. W., & Cross, C. L. (2018). Biostatistics: A Foundation for Analysis in the Health Sciences (11th ed.). Wiley. ISBN: 978-1118302798.
5. Barah, P., Bhattacharyya, D. K., & Kalita, J. K. (2021). Gene Expression Data Analysis: A Statistical and Machine Learning Perspective. CRC Press. ISBN: 978-0367338893.
6. Parmigiani, G., Garrett, E. S., Irizarry, R. A., & Zeger, S. L. (2003). The Analysis of Gene Expression Data: Methods and Software. Springer. ISBN: 978-0387955773.
7. Rangayyan, R. M. (2004). Biomedical Image Analysis. CRC Press. ISBN: 978-0849396953.
8. Hartvigsen, G. (2021). A Primer in Biological Data Analysis and Visualization Using R. Columbia University Press. ISBN: 978-0231202138.

Semester 2

PBSC201: Molecular Basis of Plant Development

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSC201: Molecular Basis of Plant Development	4	3	0	1	B.Sc. in any branch of Science	NA

Learning Objectives

The objective of this course is to provide an in-depth understanding of plant differentiation, development, and regulatory mechanisms. Students will explore key concepts such as totipotency, organogenesis, and tissue differentiation, along with light perception, plant growth, leaf and root development, floral induction, and reproductive processes. The course also covers the hormonal and molecular control of plant development, including seed development, dormancy, germination, senescence, and programmed cell death.

Learning Outcomes

Upon completion, students will have a comprehensive understanding of plant growth and developmental processes, from cellular differentiation to reproductive mechanisms. They will be able to analyze the molecular and genetic regulation of plant responses to environmental signals, particularly light. Students will gain expertise in light and hormonal control of plant development. Students will develop the skills to analyze the developmental stages of microspores and embryos. The course will enhance their ability to conduct research in plant biology and apply knowledge in crop improvement.

Course Content (45 hours)

Unit 1: Plant Differentiation and Photomorphogenesis -- Totipotency, meristems, organogenesis, adventive somatic embryogenesis, apomixis, trichome and stomata; phloem and xylem differentiation; gametogenesis and embryogenesis; Skotomorphogenesis and photomorphogenesis; Molecular mechanisms of light perception, signal transduction and gene regulation; Biological clocks and their genetic and molecular determinants. 14 hours

Unit 2: Leaf and Root Development -- Molecular basis of leaf development and polarity establishment; Venation patterns in leaves; Shoot branching and architecture; Hormonal control of leaf development; Stomatal development and movement; Phyllotaxy. Root apical meristem (RAM), Primary and secondary root development, Root hair and Root system architecture (RSA), hormonal control of root development. 12 hours

Unit 3: Floral Induction and Regulation of Gametogenesis and Embryogenesis -- Photoperiodism and its significance; Vernalization and hormonal control; Inflorescence and floral determination; Molecular genetics of floral development and floral organ differentiation: floral development in *Arabidopsis* and *Antirrhinum*; Formation of male and female gametes, pollination and fertilization; Self incompatibility; Cytoplasmic inheritance; Epigenetic imprinting; Embryo formation and cell lineage development in *Arabidopsis* and Maize. 8 hours

Unit 4: Seed Development, Dormancy, Germination and Programmed Cell Death (PCD) -- Seed maturation and dormancy; Hormonal control of seed germination, development, and seedling growth; Mobilization of food reserves during seed germination; Cell death, PCD, and apoptosis; Senescence in plants and its regulation; PCD during seed development, leaf development, and reproductive development; Energy and oxidative metabolism during senescence; Hormonal and environmental control of senescence. 11 hours

Practicals (30 hours)

1. Study of photomorphogenesis and skotomorphogenesis (by using mutant).
2. Analysis of microspore development.
3. Study of root differentiation using cytokinin markers.
4. Estimation of chlorophyll degradation during leaf senescence.
5. Study of embryo development.

Suggested Readings:

1. Gilbert, S. F. (2000) Developmental Biology. INC Publishers, USA. ISBN: 9780197699782.
2. Westhoff, P. (1998) Molecular Plant Development: from gene to plant. The Bath Press, UK. ISBN: 9780198502043.
3. Wolpert, L., Tickle, C., Martinez, A. (2015) Principles of Development. Oxford Publishers, UK. ISBN: 9780198709886.
4. Buchanan, B. B., Gruissem, W., Jones, R. L. (2015) Biochemistry & Molecular Biology of Plants. John Wiley & Sons, Ltd, UK. ISBN: 9780470714218.
5. Taiz, L. and Zeiger, E., Moller, I. M. and Murphy, A. (2015) Plant Physiology and Development. Sinauer Associates Inc. Publishers, USA. ISBN: 9781605352558.

Semester 2

PBSC202: Plant Biochemistry and Metabolism

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSC202: Plant Biochemistry and Metabolism	4	3	0	1	B.Sc. in any branch of Science	NA

Learning Objectives

Plant biochemistry and metabolism is the study of biomolecules, biochemical processes, and the pathways of chemical energy flow. This course is designed to impart critical knowledge on plant-specific primary metabolism from a more mechanistic perspective, including photosynthesis, respiration, and metabolism of carbohydrates, lipids, amino acids and nucleotides. The course will also provide information on the uptake, transport and assimilation of nutrients as well as long-distance transport mechanisms in plants. Furthermore, students will also learn to appreciate the importance of secondary metabolites produced by plants.

Learning Outcomes

This paper will lead to a comprehensive understanding of the different metabolic processes operating in a plant system. It would provide insights into the structural diversity of various biomolecules, their movement, synthesis and turnover. It would also help in developing an understanding of the key components in metabolic pathways, with emphasis on the genetic improvement of quality traits.

Course Content (45 hours)

Unit 1: Carbon Assimilation in Photosynthesis, and Uptake and Assimilation of Nutrients -- Light absorption and energy conversion; Calvin Cycle (C_3), Hatch-Slack pathway (C_4), Crassulacean Acid Metabolism (CAM), Reductive pentose phosphate pathway, Carbon dioxide uptake and assimilation, photorespiration, glycolate metabolism; Enhancing photosynthetic carbon assimilation by genetic engineering; Overview of essential mineral elements, molecular physiology of nutrient acquisition (Nitrogen, Potassium, Sulphur, and Phosphorus), role of essential mineral elements in plants; Nitrate uptake, assimilation and transport, nitrate reduction, pathways of ammonia assimilation, reductive amination, trans-amination; Regulation of transport and assimilation of essential nutrients. 17 Hours

Unit 2: Biological Oxidation and Release of Energy -- Glycolytic pathway, Kreb's cycle, high energy compounds; Oxidative phosphorylation; Chemiosmotic hypothesis; Pentose phosphate shunt pathway; Regulation of citric acid cycle and cytochrome pathway; Interactions between mitochondria and other cellular compartments. 10 Hours

Unit 3: Metabolism of Biomolecules and Secondary Metabolites -- Composition, structure and function of biomolecules (carbohydrates, lipids, proteins, and nucleic acids), biosynthesis, inter-conversion and breakdown of carbohydrates and lipids, metabolism of nucleotides and amino acids; Biosynthesis of phenolic compounds, isoprenoids, alkaloids, glucosinolates and flavonoids, phenylpropanoid pathway, mevalonate (MVA) pathway, methylerythritol phosphate pathway; Importance of secondary metabolites; Metabolic engineering of secondary metabolite production; Biotechnological applications of secondary metabolites. 12 Hours

Unit 4: Long-distance Transport Mechanisms in Plants -- Transport of water: long-distance transport and short-distance transport events between xylem and nonvascular cells, transport modules, specific water channels, turgor and stomatal movements, translocation of ions and solutes from soil; Ion transport and solute movement; Passive and Active transport, Short-distance transport between phloem and nonvascular cells; Source-sink relationship, mechanisms of loading and unloading of photoassimilates. 6 hours

Practicals (30 hours)

1. Substrate inducibility of nitrate reductase (NR) enzyme.
2. Determination of optimal pH for nitrate reductase activity.
3. Spectrophotometric assay of acid phosphatase.
4. Isolation of chloroplastic proteins and resolve them using SDS-PAGE.
5. Activity of mitochondrial marker enzyme, succinate dehydrogenase.

Suggested Readings:

1. Buchanan, B., Gruissem, W. and Jones, R. (2000) Biochemistry & Molecular Biology of Plants. American Society of Plant Physiologists, USA. ISBN: 9780470714225.
2. Dey, P.M. and Harborne, J.B. (1997) Plant Biochemistry. Academic Press, USA.
3. Metzler, D. E. (2007) Biochemistry. Academic Press, USA. ISBN: 9780122146749.
4. Nelson D. L. and Cox, M. M. (2017) Principles of Biochemistry. W H Freeman & Co., USA. ISBN: 9781319108243.
5. Stryer L., Berg, J. M. and Tymoczko, J.L. (2002) Biochemistry. W.H. Freeman & Co., USA. ISBN: 9780716746843.

6. Ashihara, H., Crozier, A., Komamine, A. (2011). Plant Metabolism and Biotechnology, Wiley. ISBN: 9780470747032.
7. Piechulla, B., Hans-Walter, H. 6th Edition (2024). Plant Biochemistry, Elsevier, Academic Press. ISBN: 9780443266164.

Semester 2

PBSC203: Eukaryotic Gene Expression and Regulation

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSC203: Eukaryotic Gene Expression and Regulation	4	3	0	1	B.Sc. in any branch of Science	NA

Learning Objectives

This course provides a detailed understanding of eukaryotic genome structure, regulation, and function. It emphasizes advancements in genome sequencing, epigenetics, and functional genomics, including CRISPR-Cas technologies, while exploring their applications in agriculture and human health. Students will develop theoretical knowledge and practical skills to analyze and manipulate genomic systems.

Learning Outcomes

Upon successful completion of this course, students will gain a comprehensive understanding of genome organization, gene regulation, and functional genomics. It will equip them with the ability to interpret high-throughput genomic data and understand regulatory mechanisms at multiple levels. Students will be able to apply this knowledge to genome editing, crop improvement, and medical research. They will also be able to propose innovative solutions to agricultural and health-related challenges by leveraging insights from transcriptional regulation, epigenetics, and emerging genomic technologies.

Course Content (45 hours)

Unit 1: Genomes and Comparative Genomics -- Genome structure and organization; Structure of chromatin and chromosomes; Genome complexity; Nuclear territories; Chromosomal Conformation studies (Hi-C); Unique and repetitive DNA; Evolution of gene families; Advances in genome sequencing technologies (Next-gen and 3rd-gen methodologies, Illumina, PacBio, Nanopore, etc.) and assembly; Optical Genome mapping; Comparative genomics of model organisms (Arabidopsis, rice, humans, and non-model species); Functional annotation through phylogenetic footprinting and multi-genome alignment; Impact of repetitive and transposable elements on genome evolution. 15 hours

Unit 2: Epigenetic and Transcriptional Regulation of Gene Expression -- Mechanisms of DNA methylation and histone modifications; Role of non-coding RNAs and chromatin remodeling in transcriptional regulation; Environmental and developmental epigenetic reprogramming; Case studies: Epigenetic regulation in flowering and stress responses. Promoter and enhancer dynamics; Mechanisms of RNA polymerase recruitment and mediator complex functions; Latest insights into transcription factors, co-activators, and repressors; Chromatin looping and transcription factories. 10 hours

Unit 3: Post-transcriptional Translational and Post-translational Regulation – RNA splicing mechanisms and alternative splicing. RNA editing, stability, transport, and degradation pathways. Regulatory roles of microRNAs, siRNAs, and lncRNAs. Insights into translational regulation and protein synthesis. Global proteomics and functional characterization of protein complexes. Role of post-translational modifications (e.g. phosphorylation, ubiquitination, etc.) and degradation in cellular processes. 10 hours

Unit 4: Functional Genomics and Genome Editing and their Applications-- High-throughput RNA sequencing (single-cell transcriptomics); Spatial Transcriptomics. CRISPR-Cas technologies: principles and applications; Gene Function validation through knockouts, knockdowns, TILLING, and transposon-tagging. Engineering crops with enhanced traits (e.g., drought resistance, pest tolerance); Case studies in transcriptional regulation and its relevance to diseases (e.g., cancer, diabetes). 10 hours

Practicals (30 hours)

1. Plant DNA extraction and quality assessment.
2. Plant RNA isolation and quality assessment.
3. RT-PCR for gene expression analysis.
4. Reporter gene assay for promoter activity (GUS assay, visualization of GFP).
5. CRISPR-Cas9 gene editing (experimental and guide RNA design).

Suggested Readings:

1. Berg, J. M, Tymoczko, J. L., Stryer, L. (2012) Biochemistry. WH Freeman and Company, New York. ISBN-13: 978-1429229364.
2. Buchanan, B. B., Gruissem, W. and Jones, R. (2015) Biochemistry & Molecular Biology of Plants. John Wiley & Sons, Ltd., West Sussex. ISBN-13: 978-0470714218
3. Kahl, G. and Meksem, K. (2008) The Handbook of Plant Functional Genomics. Wiley-VCH Verlag GmbH & Co., Germany. ISBN-13: 978-3527318848
4. Krebs, J. E., Goldstein, E. S. and Kilpatrick, S. T. (2014) Lewin's Genes XI. Jones and Bartlett Publishers, LLC, Burlington. ISBN-13: 978-1449659851
5. Latchman, D. S. (2015) Gene Control. Garland Science, New York.

6. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., Martin, K. C. (2016) Molecular Cell Biology. WH Freeman and Company, New York. ISBN-13: 978-1464183393
7. Stewart Jr., C. N, (2016) Plant Biotechnology and Genetics: Principles, Techniques and Applications. John Wiley & Sons, Inc., New Jersey. ISBN-13: 978-1118820124

Semester 2

PBSE204: Cell Signaling and Communication

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSE204: Cell Signaling and Communication	4	3	0	1	B.Sc. in any branch of Science	NA

Learning Objectives

This course aims to provide a comprehensive understanding of cellular signaling and communication in different organisms. It will cover fundamental signaling pathways, receptor mechanisms, primary and second messengers, and their roles in cellular responses. Students will explore the molecular basis of cell cycle regulation and hormone signaling, with a special focus on plant hormones and their roles in stress responses, growth, and development. The course integrates key regulatory mechanisms, emphasizing experimental insights and biological relevance.

Learning Outcomes

The candidate would learn about cellular signaling and communication, controlling a myriad of cellular processes, and coupling the cellular process with external and internal signals/stimuli. The candidate will develop an essential understanding of how cells communicate with each other and respond to external stimuli, essentially governing all cellular functions like growth, development, and even cell death, making it fundamental to comprehending complex biological processes.

Course Content (45 hours)

Unit 1: Basic Understanding of Cellular Signaling and Communication -- External and internal signals; Different signaling pathways; Analogy of signaling pathways to electronic circuitry; Stimulus response-coupling; Cellular communication through receptors and plasmodesmata; Two-component system; G-protein coupled receptors, receptor tyrosine kinase, receptor-like kinase, ion channel receptor, other cell surface receptors, intracellular hormone receptors, intracellular ligand-receptor. 10 hours

Unit 2: Primary and Second Messengers -- Growth factors and hormones in animals (EGF, interleukins, cytokines, insulin, etc.); Plant hormones (auxins, cytokinins, gibberellins, abscisic acid, etc.); Second messengers (Ca^{2+}, ROS, IP_3, cAMP, cGMP, DAG, etc.). 5 hours

Unit 3: Signaling Pathway in Prokaryotes, Animals, and Plants -- Histidine kinase-based signaling, GPCR-based signaling, receptor tyrosine kinase-based signaling, receptor kinase-based signaling, MAP-kinase-based signaling, Ca^{2+} signaling, phospholipid-based signaling, cyclic nucleotide (cAMP/cGMP)-based signaling; Role of protein kinases and phosphatases in signaling pathways. 12 hours

Unit 4: Plant Hormones Signaling and Regulation of Cell Cycle -- Signal perception of auxin, ABA, GA, cytokinins, ethylene, brassinosteroids, jasmonic acid, salicylic acid, strigolactones, etc.; Regulation of gene expression during signal transduction; Role of mutants in understanding hormone action; Regulation of biotic and abiotic stresses by phytohormones. Overview of cell cycle, progression to mitosis and meiosis; Cell cycle checkpoints, role of cyclin and cyclin-dependent kinases. 18 hours

Practicals (30 hours)

1. Effect of stress signals on growth kinetics of E. coli.
2. Analysis of a calcium sensor and its effector kinase by yeast two-hybrid growth assay.
3. Effect of stress stimuli on plant signaling mutants by analyzing the growth phenotype.
4. Localization of cellular auxin biosensor, DR5::GFP in the roots of Arabidopsis.
5. Effect of abiotic stress signals on key signaling gene expression in Arabidopsis thaliana.

Suggested Readings:

1. Gomparts B.D., Kramer I.M., Tatham P.E.R. (2009) Signal Transduction, Academic Press, USA. ISBN: 9780080919058.
2. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P. (2015) Molecular Biology of the Cell. Garland Publishing, Taylor & Francis Group, USA. ISBN: 9780815344322.
3. Buchanan BB, Gruissem W, Jones RL (2015) Biochemistry and molecular biology of the plants American Society of Plant Physiologists, USA. ISBN: 9780470714218.
4. Karp, J. G., Iwasa, J., Marshall, W. (2019). Cell and Molecular Biology. John Wiley & Sons, USA. ISBN: 9781119598169.
5. Kleinsmith, L. J. and Kish, V. M. (1997) Principles of Cell & Molecular Biology. Harper Collins College Publishers, USA. ISBN: 9780065004045.
6. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretsher, A., Ploegh, H., Amon, A., Martin, K. (2016) Molecular Cell Biology. Freeman & Co., USA. ISBN: 9781464183393.

Semester 2

PBSE205: Plant-Environment Interactions

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSE205: Plant-Environment Interactions	4	3	0	1	B.Sc. in any branch of Science	NA

Learning Objectives

Adverse environmental conditions significantly impact plant survival and productivity. The paper aims to provide an in-depth understanding of how plants perceive and interact with their environments. Students will learn about the effect of different stresses on plant growth and development, the impact of climate change on plant-environment interactions, and how plants adapt to these changing conditions. The course will introduce experimental approaches, modern techniques, and analytical tools for studying plant stress biology.

Learning Outcomes

Students will be able to understand the interactions between plants and their environment and understand their significance in agriculture and ecology. They will be able to evaluate the changes that plants undergo under challenging conditions and differentiate between the responses to biotic and abiotic stresses. Students will design and execute experiments using physiological, biochemical, and molecular techniques to study plant responses and adaptations. Students will be able to propose innovative solutions for mitigating the adverse effects of environmental stresses on crop productivity using advanced molecular biology and bioengineering approaches. Based on their knowledge they can develop strategies for developing stress-tolerant plants and their applications in sustainable agriculture and environmental remediation.

Course Content (45 hours)

Unit 1: Plant-Environment Interactions and Plant Stress Responses - Overview of abiotic and biotic factors and plant responses; adaptation strategies in different ecosystems (desert, halophytes, aquatic plants, etc.); Role of plant microbiomes in environmental interactions; Stress perception; Stress signal transduction pathways; Role of phytohormones; Epigenetic modifications and non-coding RNAs in plant stress adaptation; Crosstalk between different signaling pathways; Concept of phenotypic plasticity and stress memory in plants 8 hours

Unit 2: **Abiotic Stress Responses** -- Types of abiotic stress factors; Climate change and pollution; Physiological, morphological, biochemical, and molecular changes in plants against different abiotic stresses; Stress tolerance in crops through allelic variation; Genomic and transcriptomic approaches in abiotic stress research; Engineering plants for abiotic stress resilience; Phytoremediation and environmental biotechnology. 12 hours

Unit 3: **Biotic Stress Responses and Symbiotic Interactions** -- Types of biotic stresses; Molecular basis of plant-pathogen interactions (compatible vs. incompatible); Plant defense mechanisms against biotic agents (PTI and ETI); Plant disease resistance and susceptibility genes; Role of Systemic Acquired Resistance (SAR), Induced Systemic Resistance (ISR), and Hypersensitive Response (HR); Role of secondary metabolites; Plant immunity and priming; Effect of climate change on biotic interactions; Genetic and molecular basis of plant-insect interaction; Diversity in parasitic plants; Molecular mechanisms of host-parasite interactions, host plant pre- and post-attachment defense responses; Role of mobile RNAs and proteins in parasitism and defense responses; Rhizobial symbiosis and molecular regulation of nodule development; Interactions with arbuscular mycorrhizal fungi (AMF); Other mutualistic associations; Genomic insights into symbiotic relationships. 18 hours

Unit 4: Experimental Approaches and Applications -- Techniques to study plant stress physiology; Utility of model plant systems (*Arabidopsis*-*Pseudomonas* interaction, Rice-*Magnaporthe* interaction, etc.); Advanced techniques in high-throughput phenotyping, multi-omics approaches, advanced imaging techniques; Use of bioinformatics and AI in predicting plant stress responses; Case studies for development of climate-smart crops; Applications of synthetic biology, breeding, and transgenic technology for sustainable agriculture. 7 hours

Practicals (30 hours)

1. Effect of heat stress on seed germination of Arabidopsis.
2. Determination of membrane stability index (MSI) of plant tissues exposed to drought stress.
3. Detection of reactive oxygen species (ROS) in salt-stressed rice plants.
4. Detection of plant pathogen and disease diagnosis by loop-mediated isothermal amplification (LAMP).
5. Detection of hypersensitive response (HR) during R-Avr interaction in *Nicotiana benthamiana* leaves.

Suggested Readings:

1. Tuteja, N. and Gill, S.S. (2013) Climate Change and Plant Abiotic Stress Tolerance.; Wiley-VCH Verlag GmbH & Co. KgaA. eISBN: 9783527675265.
2. Buchanan, B.B., Gruissem, W. and Jones, R.L. (2015) Biochemistry and Molecular Biology of Plants (2nd Edition). Wiley, USA. ISBN: 9781118502198.
3. Dickinson, M. (2003) Molecular Plant Pathology.; BIOS Scientific Publishers - Taylor & Francis Group. ISBN: 9781859960448.
4. Wolpert, T., Shiraishi, T., Collmer, A., Akimitsu, K. and Glazebrook, J. (2017) Genome-enabled analysis of plant-pathogen interactions. ISBN: 9780890544983.
5. Hirt, H. (2009) Plant Stress Biology: From Genomics to Systems Biology. 1st edition. Blackwell Publishers. ISBN: 978352732290.
6. Hull, R. (2014) Plant Virology. 5th Edition, Academic Press, USA. ISBN: 9780123848710.
7. Jenks, M.A. and Hasegawa, P.M. (2014) Plant Abiotic Stress. 2nd Edition, Wiley-Blackwell. ISBN: 9781118412176.
8. Aftab, T. (2023) New Frontiers in Plant-Environment Interactions: Innovative Technologies and Developments (Environmental Science and Engineering). Springer International Publishing AG. 1st edition. ISBN: 978-3031437281.
9. Huang, B. (2006) Plant-Environment Interactions. 3rd edition. CRC Press. ISBN: 978084933727. https://plantstress.com/

Semester 2

PBGE206: Proteomics, Metabolomics and Elementomics

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBGE206: Proteomics, Metabolomics and Elementomics	4	3	1	0	B.Sc. in any branch of Science	NA

Learning Objectives

Protein, metabolite, and ionic/element profiles in living systems are important to understand the regulatory and metabolic capacity of the system. The primary objective of this course is to equip students with the principles of proteome, metabolome, and elementome. The course aims to develop knowledge in the application of state-of-the-art technologies designed to understand the proteome, metabolome and elementome of different organisms, protein modification, and the complexities of protein-protein interactions and metabolic outcomes. There will be a strong emphasis on how these technologies are applied to the agriculture and health sectors.

Learning Outcomes

Students would develop a detailed understanding of the state-of-the-art techniques and analysis methods for the study of the plant proteome, metabolome, and elementome. They will be able to carry out basic experimental design for a given biological condition and compare methods to study proteomics, metabolomics, and elementomics. They will learn to carry out data analysis and skills to interpret data, such as identification of peptides/proteins/metabolites and comparison of proteomes, elementomes, and metabolomes between different groups of samples.

Course Content (45 hours)

Unit 1: Introduction to Proteomics, Metabolomics, and Elementomics -- Introduction to 'Omics'; Protein structure folding and function; Types of Proteomics: structural, functional and expression; Basics and workflow design of proteomics technology; Comparative proteomics; Metabolites and their importance; Elements and their significance; Technological advancements in multi-omics studies; Importance in agriculture and health sciences. 6 hours

Unit 2: Tools and Techniques in Proteomics -- Principles and applications of the separation technology; 1-D and 2-D Polyacrylamide Gel Electrophoresis (PAGE), workflow, high-throughput methods, importance and applications in proteomics; Proteomic Profiling: protein sequencing, Liquid Chromatography and Mass Spectrometry (LC-MS/MS), quantitative proteomics, advanced methods in proteomics; Isotope Coded Affinity Tag based Protein Profiling (ICAT), Isobaric Tags for Relative and Absolute Quantitation: iTRAQ, AQUA, ESI-Q-IT-MS; SELDI-TOF-MS, SWATH), database search, protein identification, and pathway analysis; Post-translational modifications and their profiling; High-throughput methods for detection of protein-protein interactions and interactions of proteins with other biomolecules; Immunoproteomics: Overview of immune systems; Utility of antibodies in routine laboratory experiments; Serological proteome analysis; Protein microarrays (analytical and functional), protein array detection methods; Antigen identification by antigen capture and mass spectrometry; Characterization of the cell-mediated immune response by cytokine detection and quantification; Immuno-PCR; Immunoproteomics for major histocompatibility complex (MHC) peptides 18 hours

Unit 3: Metabolomics -- Types of metabolites; Definition and scope of metabolomics; Sample preparation and extraction techniques; Separation and detection methods: gas chromatography (GC), high-performance liquid chromatography (HPLC), mass spectrometry (MS) secondary ion MS (SIMS), desorption electrospray ionization (DESI), laser ablation electrospray ionization (LAESI), Nuclear Magnetic Resonance (NMR); Statistical tools for data analysis. 11 hours

Unit 4: Elementomics -- Relevance of mineral nutrients and trace elements; Atomic absorption spectroscopy; High-throughput elemental profiling using inductively coupled plasma-mass spectroscopy (ICP-MS), inductively coupled plasma-optical emission spectroscopy (ICP-OES), Energy Dispersive X-ray Spectroscopy (EDS), X-Ray fluorescence spectroscopy, atomic neutron activation analysis; Elemental data analysis. 10 hours

Suggested Readings:

1. Antonio, C. (2018). Plant Metabolomics: Methods and Protocols (Methods in Molecular Biology). Humana Press, USA. ISBN: 9781493992942.
2. Branden, C. I. and Tooze, T. (1999) Introduction to Protein Structure. Garland Publishing, USA. ISBN: 9780815323051.
3. Saito, K., Dixon, R. A. and Willmitzer, L. (2006) Plant Metabolomics (Biotechnology in Agriculture and Forestry). Springer, USA. ISBN: 9783540297819.
4. Lesk, A. M. (2010) Introduction to Protein Science: Architecture, Function and Genomics. Oxford University Press, UK. ISBN-0199541302.
5. Lammerhofer, M. and Weckwerth, W. (2013). Metabolomics in Practice: Successful Strategies to Generate and Analyze Metabolic Data. Oxford University Press, UK. ISBN: 9783527330898.

6. Weckwerth, W. (2007) Metabolomics: Methods and Protocols (Methods in Molecular Biology). Humana Press, USA.[1] ISBN: 9781588295613.
7. Fulton, K. M., Baltat, I., and Twine, S. M. (2019). Immunoproteomics methods and techniques. Immunoproteomics: methods and protocols. ISBN: 9781493995967.

Semester 2

PBSD207: Plant Tissue Culture and Transformation Methodologies

Course title & code	Credits	Credit Distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorials	Practical/ Practice		
PBSD207: Plant Tissue Culture and Transformation Methodologies	2	0	0	2	B.Sc. in any branch of Science	NA

Learning Objectives

This course aims to provide hands-on training in plant biotechnology techniques, including plant tissue culture, haploid production, protoplast isolation, plant genetic transformation, and virus-induced gene silencing. Students will gain practical experience in media preparation, sterile techniques, regeneration protocols, and molecular screening for plant improvement and research applications.

Learning Outcomes

Upon completion of this course, students will develop proficiency in key plant biotechnology methods, enabling them to perform plant tissue culture, genetic transformation, and molecular validation independently. They will acquire skills in protoplast manipulation, haploid generation, plant transformation and gene silencing, preparing them for careers in plant tissue culture, crop improvement, and biotechnological innovations.

Hands-on Training (60 hours)

Unit 1: Plant Tissue Culture, Micropropagation, and Protoplast Isolation -- Media preparation, surface sterilization of leaf discs of tobacco/hypocotyls of tomato), callus induction and proliferation, shoot and root regeneration, establishment of plantlets; Haploid Production through Androgenesis: Selection of specific stages of anthers of tobacco/*Datura*, surface sterilization, axenic culture, haploid plant generation; Plant protoplast isolation and transfection: protoplast isolation from leaves/roots of wheat seedlings, viability check using dyes, transformation using PEG method, visualization under confocal microscope. 30 hours

Unit 2: Plant Genetic Transformation and Virus-induced Gene Silencing (VIGS) -- *Agrobacterium tumefaciens*-mediated transformation of Arabidopsis plants using floral dip method, transformants screening, transgene insertion validation by PCR; Agroinfiltration of TRV-*pds* constructs in tobacco leaves, phenotyping, and screening of VIGS lines. 30 hours

Suggested Readings:

1. Gilbert, S. F. (2000) Developmental Biology. INC Publishers, USA. ISBN: 9780197699782.
2. Westhoff, P. (1998) Molecular plant development: from gene to plant. The Bath Press, UK. ISBN: 9780198502043.
3. Wolpert, L., Tickle, C., Martinez, A. (2015) Principles of Development. Oxford Publishers, UK. ISBN: 9780198709886.
4. Bhojwani, S.S. and Razdan, M.K., 1986. Plant tissue culture: theory and practice. Elsevier.
5. Boisson-Dernier, A., Chabaud, M., Garcia, F., Bécard, G., Rosenberg, C., and Barker, D. G. (2001). *Agrobacterium rhizogenes*-transformed roots of *Medicago truncatula* for the study of nitrogen-fixing and endomycorrhizal symbiotic associations. Molecular Plant-Microbe Interactions 14(6), 695–700. DOI: 10.1094/MPMI.2001.14.6.695.
6. Rössner, C., Lotz, D., and Becker, A. (2022). VIGS goes viral: How VIGS transforms our understanding of plant science. *Annual Review of Plant Biology*, 73, 703–728. DOI: 10.1146/annurev-arplant-102820-020542.