teri school of advanced studies

10, Institutional Area, Vasant Kunj,
New Delhi 110070

52nd MEETING OF THE ACADEMIC COUNCIL

MINUTES OF THE FIFTY SECOND MEETING OF THE ACADEMIC COUNCIL HELD ON 08 AUGUST 2022 AT 10.00 A.M.

PRESENT

The following members of the Academic Council attended the meeting:

Members

Professor Prateek Sharma, Chairperson
Professor Shaleen Singhal
Professor Anandita Singh
Professor Ramakrishnan Sitaraman
Professor Sagnik Dey
Mr Shubhashis Dey
Dr Sabhyata Bhatia
Professor Vinay Shankar Prasad Sinha
Professor Arun Kansal
Dr Sudipta Chatterjee
Dr Naqui Anwer
Dr Sukanya Das
Dr Chaithanya Madhurantakam
Dr Anu Rani Sharma
Dr Montu Bose
Dr Chander Kumar Singh
Dr Seema Sangita, Controller of Examination
Mr Kamal Sharma, Secretary

Special Invitee

Dr Shashi Bhushan Tripathi

Prof. P.S.N. Rao, Prof Shreekant Gupta, Mr Manoj Chugh, Mr Rajesh Ayapilla, Mr Rahul Mittal and Dr Sapan Thapar could not attend the meeting.

Prof Prateek Sharma welcomed the Academic Council members and introduced the new external members who have been included in the Academic Council and hoped that the institution would be benefited with their experience and valuable inputs before requesting the Registrar to take up the agenda items.

Item No. 1: To confirm the minutes of the Fifty First Meeting of the Academic Council held on 28 April 2022. The minutes of the Fifty First Meeting of the Academic Council, held on 28 April 2022, were circulated to the members. No comments have been received so far.

The Academic Council may, therefore, consider confirming the minutes, as circulated.

TS/AC/52.1.1 The Council resolved that the minutes of the 51st Academic Council Meeting held on 28 April 2022 be confirmed.

Item No. 2: To consider and approve courses to be offered in the Semester 3 of M.Sc. Biotechnology Programme. Dr. Shashi Bhushan Tripathi presented the courses to be offered in the third semester of M.Sc Biotechnology Programme offered by the Department of Biotechnology commencing from 17 August 2022. Prof. Tripathi requested the Academic Council to approve the below-mentioned six courses which are placed at **Enclosure 1**. He further stated that these courses were approved by the Board of Studies.

1. Bioprocess Engineering and Environmental Biotechnology
2. Functional Genomics in Plants
3. Gene Expression Analysis and Transcriptomics
4. Proteomics and Protein Engineering
5. Bioethics, IPR and Regulations in Biotechnology
6. Biotechnology Laboratory- Part 3

The members while approving the courses suggested that format of the courses should be uniform which may be looked into.

TS/AC/52.2.1 The Academic Council resolved to approve the courses to be offered in the Semester 3 of M.Sc. Biotechnology programme offered by the Department of Biotechnology as placed at **Enclosure 1**.

Item No. 3: Any other item with the permission of the Chair.

(a) Prof. Prateek Sharma informed the members about the concept of Academic Bank of Credits. He also brought to the notice of the members that participants of few short-term training programmes having requisite number of credit hours can also earn credit, once approved by the Academic Council. He cited example of Entrepreneurship on Solid Waste Management. Prof. Arun Kansal informed that it has been designed to cater to the needs of the mid-career professionals. Prof. Kansal further informed that it is intended to make this course as an elective course with credit for students to benefit from it and the same will be put up to the Academic Council for approval through Board of Studies.

(b) Prof Sagnik Dey stated we can look for short term courses in the field of air quality management as well as air pollution epidemiology or in general environmental epidemiology in the country. In this regard we can have discussion with CAPS India Network.

(c) Mr Shubhashis Dey stated that short term courses can be focussed to train policymakers as TERI SAS already has expertise in this area. He emphasised the need of collaboration with few foreign universities in this regard. He also mentioned that there is a need to look at carbon credits or green credits as well.

(d) Dr Sabhyata Bhatia opined that short-term certificate courses could be initiated on Informatics/ Bioinformatics as OMICs approaches underpin every aspect of biological sciences. She mentioned that analysis of voluminous genomics/NGS, transcriptomics, and proteomics data is the need of the Biotech industry in current times. Informatics courses will be therefore popular. Dr Bhatia also suggested that short-term courses be designed around biotechnology management aspects since industries are not limited to R&D but also deal in sales, marketing, etc. and hence these courses would be useful.

(e) Dr Naqui Anwer informed the members that TERI SAS had applied for reassessment of NAAC in the month of December 2021 after addressing the queries related to Data Validation and Verification (DVV). We have made payments and have proposed to them three dates the first being 23rd to 25th August and the next two dates are 15 days apart. We are expecting to hear about the visit of the Pear Team shortly.

Prof. Prateek Sharma thanked all the members for providing their valuable inputs and stated that he looks forward to their continued support.

There being no other items for discussion, the meeting was adjourned with a vote of thanks to the Chair at 1230 hours.

Sd/
Kamal Sharma
Registrar (Acting)

Enclosure:-
Enclosure 1. Course outline of Semester 3 of M.Sc. Biotechnology programme

Distribution:-
Electronic Copy:
1. Vice Chancellor, TERI School of Advanced Studies
2. All members of Academic Council
3. Website

Printed Copy: Registrar Office

Enclosure 1

<table>
<tr><td colspan="5">Course title: Bioprocess Engineering and Environmental Biotechnology</td></tr>
<tr><td>Course code: BBP162</td><td>No. of credits: 3</td><td colspan="2">L-T-P: 30-15-0</td><td>Learning hours: 45</td></tr>
<tr><td colspan="5">Pre-requisite course code and title (if any): Science graduate</td></tr>
<tr><td colspan="5">Department: Department of Biotechnology</td></tr>
<tr><td colspan="2">Course coordinator:</td><td colspan="3">Course instructor</td></tr>
<tr><td colspan="5">Contact details:</td></tr>
<tr><td colspan="2">Course type: Elective</td><td colspan="3">Course offered in: Semester 3</td></tr>
<tr><td colspan="5">Course description:
The course aims to provide students with methods employed in bioprocess engineering and environmental biotechnology. The course is structured to provide the students with fundamental concepts connected to systems metabolic engineering, bio separation, bioprospecting and bioprocessing, biofuels, and bioreactors. This course will offer the students a broad sense of understanding on emerging methods used in food and industrial biotechnology using different case studies.</td></tr>
<tr><td colspan="5">Course objectives:
1. Acquainting students with concepts applied in the metabolic engineering and synthetic biology.
2. Familiarization students with upstream and downstream processing of molecules using bioreactors.
3. Providing information on new applications of biotechnology in the food industry.
4. Familiarizing the students with methods of microbial waste management and microbial treatment methods.</td></tr>
<tr><td colspan="5">Course contents</td></tr>
</table>

Module	Topic	L	T	P
1	**Metabolic Engineering and Synthetic Biology**	6	3	0
	Rational genome modifications, strain analysis and characterization, DNA assembly technologies for libraries construction: Homology based (Gibson Assembly, Circular Polymerase Extension Cloning -CPEC, Yeast Transformation-associated recombination- TAR, seamless ligation cloning extract-SLiCE, Ligase Cycling Reaction- LCR), Restriction based (Biobricks, Golden Gate), Recombinase technologies (Gap-repair, Lambda-red, Multiplex Automated Genome Engineering -MAGE and CRISPR-Cas9)			
2	**Bioprocess Engineering**	8	4	0
	Bioreactor Engineering, Anaerobic and Aerobic Bioreactors; Design, Operation, monitoring and modeling of bioprocesses; Upstream versus Downstream processing; Biochemical and biological processes for conversion of biomass to biofuels (ethanol, biogas etc.) and value-added chemicals (biochemicals and biopolymers); Circular Bioeconomy versus Linear Bioeconomy, Basics of Life Cycle Analysis (LCA) and Techno-economic Analyses (TEA), Bioprocess scaleup and Technology Transfer			
3	**Industrial Biotechnology**			
	Enzymes and Microbial Cell Factories: Engineering enzymes, Approaches for improving the enzymes functionalities, Enzyme production, purification and immobilization, Enzymes stabilization and formulation preparations, Green industrial processes, Microbial cell factories, High value drugs and nutraceuticals, Bioprospecting and Bioprocessing: Cell Culture Technology, immobilized cell technology	4	2	0

	Food Nano-Biotechnology: Engineered nanomaterials for high value food production, edible nano-coatings for perishable fruits and vegetables, micro/nano encapsulation of active food ingredients, nanomaterials for food packaging, nano-sensors for food quality and security.	4	2	0
4	**Environmental Biotechnology**			
	Fundamentals of Environmental Biotechnology; Pollution abatement (wastewater, biomass waste-agrowaste, sludges, industrial waste): Bioremediation of xenobiotics, Organic waste management: Macrophyte Treatment Systems (MaTS), Algal Treatment Systems (ATS) for resource recovery from wastewater, Integrated resource recovery (IRR), Biological Treatment Methods: *in situ* techniques (biosparging, bioventing, injection, and recovery method), *ex situ* methods (land farming, soil banking and soil slurry method), Bioleaching and Biomining, microbial catalyzed electrochemical approaches, phytoremediation; Biomass based biorefineries; Environmental monitoring (Bioindicators – Biomarkers –Biosensors –Biomonitoring –Polluted environment – Short and long term monitoring of remediated sites)	8	4	0
	Total	**30**	**15**	**0**

Evaluation criteria:
1. Minor test 1 30%
2. Minor test 2 30%
3. Major test (end semester) 40%

Learning outcomes:
1. Able to acquire a detailed understanding of various tools and methods employed for metabolic engineering. (Test 1)
2. Able to gain deep insight into the design and functioning of bioreactors used for upscaling of microbes/products. (Test 2)
3. Conceptual understanding about enzymes and applications in industry (Test2)
4. Develop understanding and production mechanism on various high value drugs and biobased molecules, and concepts of circular bioeconomy and life cycle analysis. (Test 2 and Test 3)
5. Able to capture the concepts of bioremediation, waste management and integrated resource recovery methods. (Test 3)

Pedagogical Approach:
1. Lectures and tutorials supported by critical appraisal of original research articles as case studies.
2. Peer-reviewed research articles to discuss on various modules in the course.

Skill Set:
1. Knowledge of tools and techniques used in metabolic engineering and synthetic biology based on case studies provided.
2. Knowledge of biobased molecules, biofuels, and production mechanisms.
3. Knowledge of techniques employed in bioremediation, bioleaching and biomining.
4. Gain knowledge about nanotechnology and its interdisciplinary endeavours in food biotechnology sectors

Employability:
The course will provide skillsets and knowledge that may play key role to get employed in Universities, R & D industry, Medical centres/Colleges, Research Institutes and Diagnostic centres apart from specialized units like pharma, breweries, food, dairy and agri sectors.

Materials:
Suggested Readings

1. Stephanopoulos, G. (2012). Synthetic biology and metabolic engineering. *ACS Synth. Biol.* 1, 514–525. doi: 10.1021/sb300094q
2. Lee, S., Mattanovich, D. & Villaverde, A. Systems metabolic engineering, industrial biotechnology and microbial cell factories. Microb Cell Fact 11, 156 (2012). https://doi.org/10.1186/1475-2859-11-156.
3. Choi KR, Jang WD, Yang D, Cho JS, Park D, Lee SY. Systems Metabolic Engineering Strategies: Integrating Systems and Synthetic Biology with Metabolic Engineering. Trends Biotechnol. 2019 Aug;37(8):817-837. doi: 10.1016/j.tibtech.2019.01.003. Epub 2019 Feb 5. PMID: 30737009.
4. Wang, J. W., Wang, A., Li, K., Wang, B., Jin, S., Reiser, M., et al. (2015). CRISPR/Cas9 nuclease cleavage combined with Gibson assembly for seamless cloning. *BioTechniques* 58, 161–170. doi: 10.2144/000114261
5. Liu, R., Bassalo, M. C., Zeitoun, R. I., and Gill, R. T. (2015). Genome scale engineering techniques for metabolic engineering. Metab. Eng. 32, 143–154. doi: 10.1016/j.ymben.2015.09.013
6. Nathan Danielson, Sarah McKay, Paul Bloom, Jennifer Dunn, Neal Jakel, Timothy Bauer, John Hannon, Michael C. Jewett, and Brent Shanks.Industrial Biotechnology.Dec 2020.321-332.http://doi.org/10.1089/ind.2020.29230.nda
7. Brooks, R., Chambers, M., Nicks, L. and Robonson, B. (1998) Phytomining, Trends in Plant Science, 3:359–62.
8. M. A.V. Axelos and M. V. Voorde (2017), Nanotechnology in Agriculture and Food Science, Wiley-VCH Verlag GmbH.
9. Q. R. Huang (2012), Nanotechnology in the Food, Beverage and Nutraceutical Industries, Woodhead Publishing, Cambridge, UK
10. Bailey, J.E. and Ollis, D.F. Biochemical Engineering Fundamentals, 2nd Ed., McGraw-Hill, p163-172. 1986.
11. Ricky Lambert, Bioprocess Engineering, Kaufman Press, ISBN: 9781666888027, 2022.

Additional information (if any): The course framework and modules were designed by **Dr. Chaithanya Madhurantakam.**
Inputs and suggestions were received from following adjunct faculty (TERI)
1. Dr. Amritpreet Kaur Minhas (Associate Fellow, Centre for Excellence in Agrinanotechnology Sustainable Agriculture, TERI)
2. Dr. Ruchi Agrawal (Associate Fellow, Centre for Excellence in Agrinanotechnology Sustainable Agriculture, TERI)
3. Dr. Shruti Shukla (Fellow/ Senior Scientist, TERI)

Student responsibilities:
1. Study of course material as specified by the instructor.

Reviewers:

1. **Dr. Vinay Kumar Tyagi**, Scientist D, Environmental Hydrology Division, National Institute of Hydrology (NIH), Roorkee-247667, Uttarakhand, INDIA.
2. **Dr. Vivekanand V**, Ramalingaswami fellow, Biofuels Lab, Centre for Energy and Environment, Malaviya National Institute of Technology Jaipur JLN Marg Jaipur-302 017, Rajasthan, INDIA.
3. **Dr. Banwari Lal** (Senior Director, Environmental & Industrial Biotechnology, TERI).

<table>
<tr><td colspan="4">Course title: Molecular Genetics for Plant Functional Genomics: Principles and Practice</td></tr>
<tr><td>Course code:</td><td>No. of credits: 3</td><td>L-T-P: 22-23-0</td><td>Learning hours: 45</td></tr>
<tr><td colspan="4">Pre-requisite course code and title (if any): None</td></tr>
<tr><td colspan="2">Faculty: Anandita Singh</td><td colspan="2">Department: Department of Biotechnology</td></tr>
<tr><td colspan="2">Course coordinator(s): Anandita Singh</td><td colspan="2">Course instructor(s): Anandita Singh, Shashi Bhushan Tripathi</td></tr>
<tr><td colspan="4">Contact details: asingh@terisas.ac.in</td></tr>
<tr><td colspan="2">Course type: Core course for Plant Biotechnology specialization</td><td colspan="2">Course offered in: Semester 3</td></tr>
</table>

Course description:

Transformative technological solutions emerging from plant biotechnology can tackle sustainability challenges in varied sectors including agriculture, energy, and environment. Crop genomics offers exciting possibilities to enhance production of nutritious food to feed the future world. Bio-synthetic potential of plants is being exploited to harvest solar energy for bio-fuel production and achieving CO_2 sequestration. Nonetheless, true potential of plant sciences is required to be harnessed by way of systematic, large-scale functional studies of candidate genes and intergenic regions at genome-wide level. The multi-disciplinary approach of functional genomics aims to unravel the complex relationship between genotype and phenotype. Functional genomics also aims to describe constituents of biological systems and how these interact to manifest traits.

Molecular genetics lies at the heart of functional genomics. The phenotype centric view derived from experimental validation is in sharp contrast with hypothesis driven OMICS and bioinformatics approaches. Analysis of mutant phenotypes, combined with forward mapping strategies are cornerstones for molecular genetics research. Integration of contemporary NGS driven, genome-wide tools, precision phenotyping and genome editing have accelerated gene discovery and functional characterization of genes. Advance statistical models and ML methods have been deployed to fast-track production of superior crops.

This advance level course has been designed to impart an in-depth knowledge on concepts and methodological repertoire of molecular genetics for the purpose of gene discovery and characterization. A basic understanding on principles of molecular biology, genetics and biochemistry is required to fully comprehend the topics covered in this course. Students will be briefly oriented to technologies and various online resources for functional genomics research. However, insights on genomics, genotyping methods, epi-genomics, transcriptomics, proteomics and metabolomics, are to be integrated from other courses taught in the programme. Relevant topics implied in molecular genetics are assembled in five modules given below. Case studies will be used to illustrate power of new technologies in decoding genomes and pangenomes, dissecting genetic architecture of traits, discovering novel alleles and translation of basic knowledge for design of low-input, high-yielding, climate resilient crop varieties.

Course objectives:

1. Building perspectives on integrative approaches of “Functional Genomics”
2. Promoting an understanding on genesis and scope of “Molecular Genetics”
3. Creating an in-depth understanding on forward and reverse genetics-based approaches for dissecting genotype-phenotype relationship
4. Introducing methodological repertoire of forward and reverse genetics
5. Inculcating an appreciation for power of molecular genetics and genomics in unravelling biological function, processes, and phenomena for crop improvement

Course contents

Module		L	T	P
1	**Molecular genetics and functional genomics: An overview**	1	5	
	Introduction to genomics, functional genomics and molecular genetics within “OMICS” space, concepts implicit in functional genomics (transcription profiling, genotyping, epigenetic profiling, DNA/RNA-			

	protein interactions, meta-analysis), select *in-silico* resources for gene prediction and plant functional genomics (Gramine, PlantGDB, FGENESH, eFP Browser, ArrayExpress, PlantPAN), orientation to ENCODE encyclopaedia, molecular genetics and conundrum of "forward-reverse" for establishing genotype-phenotype relationship			
2	**Linkage mapping: Identification of causal loci using experimental populations**	4	4	
	Linkage mapping and dissection of genetic architecture of traits: Phenotypes and endophenotypes; natural variation and discovery of alleles; construction of linkage maps, bi-parental and multi-parent mapping populations for high resolution trait mapping: F2, RILs (Recombinant Inbred Lines), backcross lines, NILs (Near Isogenic Lines), HIFs (Heterogeneous Inbred Families), AILs (Advanced Inter-cross Lines), pseudo-test-cross mapping, NAM (Nested Association mapping), MAGIC (multi-parent advanced generation inter-cross); map-based cloning (traditional candidate gene sequencing based positional cloning strategies; modern deep sequencing based simultaneous mapping and identification of causal mutation: SHORE maps)			
3	**Association mapping: Identification of causal alleles using natural populations**	2	2	
	Pangenomics, genomes and super-pangenomes; Linkage Disequilibrium (LD) mapping, Haplotype maps, Genome-wide association studies (GWAS), Case studies on crops including rice, wheat and orphan crops viz. chickpea and pigeonpea			
4	**Designing breeding approaches**	4	4	
	Marker assisted foreground and background selection (MAS, MABC, MARS); BSA (Bulked Segregant Analysis); natural variation and exotic genetic libraries, introgression lines; classical and modern approaches for enhancing genetic gains; integration of NGS approaches, statistical models and machine learning tools for genomic selection, AI based tools for precision phenotyping, plant to sensor and sensor to plants, GEBVs (Genomics estimated breeding values) in field crop breeding, case studies covering shuttle breeding, speed breeding and integrated framework on fast-forward breeding			
5	**Mutant Analysis for Functional Genomics**	10	8	
	Approaches for mutagenesis and mutant analyses: Chemical, physical and biological mutagenesis; genetic screens (enhancer, suppressor, modifiers); random and targeted mutagenesis; conceptual understanding of loss-, and gain-of-function mutants; integrated forward and reverse genetics for functional genomics using mutants; Insertional mutagenesis (T-DNA and transposon-tagging); systematic insertional mutagenesis for high-throughput functional genomics; genome-wide mutant libraries; TILLING (Targeted Induced Local Lesions in Genomes), Fast-neutron bombardment (DeleteAgene); RNAi based gene silencing (Intron-hairpin constructs, artificial miRNAs); Ectopic mis-expression, Activation mutagenesis (Enhancer activation tagging, promoter activation tagging) Discovery and functional analysis of cis-regulatory elements: Gene,			

	enhancers, and promoter traps; expression domain analysis of promoters, two component systems for regulated gene expression Genome editing for gene-function analysis: TALENs and advanced CRISPR derived suites and programmable nucleases for altered gene expression; modification of promoters, coding, non-coding sequences; epigenome editing, insertion of reporter gene-drives (knock-ins) Cases studies from model plant *A. thaliana*: Unravelling molecular basis of developmental and adaptive traits using integrated molecular genetics and functional genomic approaches			
	Total	**22**	**23**	

Evaluation criteria:
1. Minor test 1 30%
2. Minor test 2 30%
3. Major test (end semester) 40%

Learning outcomes:
1. An integrated view on genetics, genomics and bioinformatics for deciphering molecular basis of phenotypes **(Test 1-3)**
2. An understanding on principles of forward mapping, classical reverse genetics and genomics powered high-throughput schemes for functional analyses of genomic sequences **(Test 1-3)**
3. Technical know-how on types of mutagenesis approaches, generation and application of gain- and loss-of-function mutants **(Test 1-3)**
4. Perspectives on contemporary genome editing methods for gene function analysis **(Test 1-3)**

Pedagogical Approach:
Lectures, tutorials supported by critical appraisal of original research articles, reviews, books and book chapters, hands-on-training and demonstration of online resources

Skill Set:
1. Rationalizing deployment of suitable strategies for gene discovery and gene functional analysis
2. Proficiency in use of relevant *in-silico* tools and online resources for functional characterization of genes
3. Generating mapping populations for trait mapping
4. Constructing of linkage maps using contemporary genotyping methods
5. Using natural populations for association mapping of traits
6. Using NGS data creatively for trait mapping
7. Applying MAS, MABC and MARS in breeding programmes
8. Designing and implementing mutagenesis screens
9. Generation of knock-out, knock-down, over-expression and genome edited mutant lines for activation or interference of target genomic sequences
10. Analysing mutant genotypes, phenotypes and endo-phenotypes
11. Innovating novel strategies for gene function analysis and characterization of genomic sequences

Employability:
1. Genotyping and sequencing companies
2. Agri-biotechnology, agri-genomics and seed companies
3. Law firms and knowledge processing organizations, IP management consultancy
4. Regulatory bodies and funding agencies

Materials:
Suggested readings (Representative)
Books
1. Sharples, F. (2020) Next Steps for Functional Genomics (Proceedings of a Workshop, National Academies of Sciences, Engineering, and Medicine; Division on Earth and Life Studies; Board on Life Sciences) National Academies Press (US); Washington (DC) ISBN-13: 978-0-309-67673-1

2. Varshney, R., Pandey, M., Chitikineni A. (2018) Plant Genetics and Molecular Biology: Advances in Biochemical Engineering / Biotechnology series number 164, Springer Nature, Switzerland, ISBN: 978-3-319-91312-4
3. Varshney, R., Roorkiwal, M., Sorells M. (2017) Genomic Selection for Crop improvement: New Molecular Breeding strategies for crop improvement. Springer Nature, Switzerland, ISBN-10: 3319631683, ISBN-13: 978-3319631684
4. Alonso J.,M., Stepanova, A.,N. (2015) Plant Functional Genomics: Methods and Protocols, Humana Press, ISBN 10: 1493924435, ISBN 13: 9781493924431
5. Grotewold, E. (2010) Plant Functional Genomics. Methods and Protocols, Humana Press, ISBN 13: 9781617373862
6. Meksem, K., Kahl, G. (2005) The Handbook of Plant Genome Mapping: Genetic and Physical Mapping, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, https://doi.org/10.1002/3527603514

Required texts:
Research articles, reviews on relevant topics, websites and relevant links as provided by the instructor in lectures and tutorials

Student responsibilities:
1. Class attendance
2. Study of course materials as specified by the instructor
3. Self-study

Course Reviewers:

1. **Professor Rajeev K Varshney**
   ML, FTWAS, FAAAS, FAAS, FCSSA, FASA, FNA, FASc, FNASc, FNAAS, Director, State Agricultural Biotechnology Centre, Director, Centre for Crop & Food Innovation, International Chair in Agriculture & Food Security, Food Futures Institute, Murdoch University, Australia

2. **Professor Yashwanti Mudgil**
   Department of Botany,
   University of Delhi,
   Delhi 110007

Course title: Gene Expression Analysis and Transcriptomics					
Course code:	**No. of credits:** 2		**L-T-P:** 30-0-0	**Learning hours:** 30	
Pre-requisite course code and title (if any): None					
Department:					
Course coordinator(s):		**Course instructor(s):**			
Contact details:					
Course type: Core		**Course offered in:** Semester 3			

Course description: An understanding of the range of methods available to interrogate gene expression on a large scale as well as the correct usage and interpretation of high-throughput data is indispensable for the modern biologist. Together with its complementary course on proteomics and protein engineering, Accordingly, this course provides an overview of methods available to analyse gene transcription and complements the course titled “proteomics and protein engineering.” Starting with due emphasis to the biological complexity that high-throughput methods aim to interrogate in the first module, the course moves progressively from a description of the different techniques available and their comparative analysis to an overview of the approaches to and problems in analysis, integration and biological inference. The concluding module introduces two fast-moving areas of research – meta-omics and single-cell omics – and surveys their potential to provide insights into the heterogeneity of cellular communities.

Course objectives:
1. To present an integrative view of cellular processes at progressively complex levels.
2. To enable synthesis of isolated information in order to analyze biological phenomena in a contextually relevant manner.
3. To delineate the overarching role of evolutionary considerations at multiple levels of complexity.

Course contents

S.No	Topic	L	T	P
Module 1	**The biological problem**	**9**		
1	Regulation of gene expression in prokaryotes and eukaryotes, similarities and differences in gene regulation across the domains of life, historical impact of genetic approaches on the study of gene expression.	3		
2	Levels of regulation – transcriptional to post-translational, phenotypic plasticity and epigenetics; the impact of DNA rearrangements on gene expression.	4		
3	Evolutionary considerations in gene regulation and their role in speciation	2		
Module 2	**Tools and techniques for gene expression analysis**	**9**		
1	Low to medium throughput methods (blotting and PCR).	1	0	0
2	High throughput platforms/methods – Microarrays, RNA-seq, Nanostring, Nanopore, PacBio, pyrosequencing, flow cytometry and phenotyping of single cells	6	0	0
3	Quality control, comparison of methods – their scope and limitations	2	0	0
Module 3	**Analysis, inference and integration**	**10**		
1	Multiple hypothesis testing and the false discovery rate	2	0	0
2	Normalization, correlation and clustering to determine differential gene expression, guilt-by-association and regulatory networks	8	0	0
Module 4	**Prospects and perspectives**	**2**		
	Meta-omics and single-cell omics,	2		

	Total	**30**	0	0

Evaluation criteria:

1. Minor test 1 30%
2. Minor test 2 30%
3. Major test (end semester) 40%

Learning outcomes:

1. Detailed knowledge of gene regulatory mechanisms in across the three major kingdoms and the evolution of regulatory systems. (Test 1).
2. Understanding the methods available to analyse gene expression, their scope and limitations (Tests 2-3).
3. Ability to understand the conceptual bases of analytical approaches to derive biological information (Tests 2-3).

Pedagogical Approach:

Lectures, tutorials supported by critical appraisal of original research articles, reviews, books and book chapters, hands-on-training and demonstration of online resources

Skill Set:

1. Design and critical analysis of experimental approaches to analyse gene transcription.
2. Interpretation of data from high-throughput approaches.
3. Formulation of testable hypotheses based on gene expression data.

Employability:

1. Academic and industrial research.
2. Intellectual property firms.
3. Life science teaching at school and undergraduate levels.
4. Management and/or supervision of laboratory research in academic/industrial settings.

Materials:

Required texts

1. Campbell, A. M. & Heyer, L. J. Discovering genomics, proteomics, and bioinformatics. (CSHL Press : Pearson/Benjamin Cummings, 2007).
2. Conesa, A. *et al.* A survey of best practices for RNA-seq data analysis. *Genome Biol.* **17**, 13 (2016).
3. DeRisi, J. L., Iyer, V. R. & Brown, P. O. Exploring the metabolic and genetic control of gene expression on a genomic scale. *Science* **278**, 680–686 (1997).
4. Hughes, T. R. et al. Widespread aneuploidy revealed by DNA microarray expression profiling. *Nat. Genet*. **25**, 333–337 (2000).
5. Kirienko, N. V. & Fay, D. S. Transcriptome profiling of the C. elegans Rb ortholog reveals diverse developmental roles. *Dev. Biol.* **305**, 674–684 (2007).
6. Wittkopp, P.J. Evolution of Gene Expression. *in* The Princeton Guide to Evolution (*eds.* Losos, J. B. *et al.*) 413–419 (Princeton University Press, 2013). doi:10.1515/9781400848065-058.
7. Lovén, J. *et al*. Revisiting global gene expression analysis. *Cell* **151**, 476–482 (2012).
8. Noble, W. S. How does multiple testing correction work? *Nat. Biotechnol*. **27**, 1135–1137 (2009).
9. Shoemaker, D. D. *et al*. Experimental annotation of the human genome using microarray technology. *Nature* **409**, 922–927 (2001).
10. Wang, B., Kumar, V., Olson, A. & Ware, D. Reviving the Transcriptome Studies: An Insight Into the Emergence of Single-Molecule Transcriptome Sequencing. *Front. Genet*. **10**, 384 (2019).
11. Karahalil, B. Overview of Systems Biology and Omics Technologies. *Curr. Med. Chem.* **23**, 4221–4230 (2016).
12. Martins, R. P. The conceptual structure of evolutionary biology: A framework from phenotypic plasticity. *Eur. J. Ecol.* **4**, 111–123 (2018).
13. Stein, C. M., Weiskirchen, R., Damm, F. & Strzelecka, P. M. Single-cell omics: Overview, analysis, and application in biomedical science. *J. Cell. Biochem.* **122**, 1571–1578 (2021).

Case studies **Suggested readings** 1. Ptashne, M. A Genetic Switch, Phage Lambda Revisited. (CSHL Press, 2004, 3rd ed.) **Journals** **Other readings**
Additional information (if any):
Student responsibilities: 1. Class attendance (online/offline). 2. Study/self-study of course materials as specified by the instructor. 3. Ensuring functionality of essential IT hardware & software at their preferred location(s).

Course reviewers:

1. Prof. Vijaya Satchidanandam, Department of Microbiology and Cell Biology, Indian Institute of Science, Bengaluru (superannuated) and Adjunct Professor, St. John's Medical College, Sarjapur Road, Bengaluru – 560034
2. Dr. S. Ramachandran, Chief Scientist, Professor of the AcSIR in the Faculty of Biological Sciences, Room 130, CSIR-Institute of Genomics and Integrative Biology, Mathura Road, Near Sukhdev Vihar Bus Depot, New Delhi – 110025

Course title: Proteomics and Protein Engineering			
Course code: _	**No. of credits:** 3	**L-T-P:** 45-0-0	**Learning hours:** 45
Pre-requisite course code and title (if any): Principles of Biochemistry and Biophysics (BBP161)			
Department: Department of Biotechnology			
Course coordinator: Chaithanya Madhurantakam		**Course instructor**	
Contact details:			
Course type: Core		**Course offered in:** Semester 3	

Course description:

Protein engineering has revolutionized the field of biosciences with varied applications and this course will provide students with the concepts along with knowledge of methods and tools used to engineer proteins. Further, the topics in proteomics will deal with outcomes of functional genomics and its applications in the health sector. The myriad of techniques that have evolved in mass spectrometry aiding advanced proteomics will be dealt with in the course.

Course objectives:

1. Students will be acquainted with methods and tools for protein synthesis and separation.
2. Familiarizing students with various domains and platforms used in Mass Spectrometry and concepts related to advanced MS techniques.
3. Students will be provided with the concept of designing proteins, artificial macromolecular scaffolds, and its applications.
4. Providing students with information on techniques involved in deciphering the structure function relationship in proteins.
5. Familiarizing students with varied applications of engineered proteins.

Course contents

Module	Topic	L	T	P
Module 1: Protein Synthesis and Separation				
Protein expression, purification and separation, generation of pH gradients, IEF, 2-D PAGE, Cell-free translation systems, Random mutagenesis and selection, saturation mutagenesis (impact of mutagenesis on protein structure, solubility, and function), designed divergent evolution, receptor based QSAR methods, phage display, yeast surface display and ribosomal display mechanisms		**10**	**0**	**0**
Module 2: Proteomics				
Mass Spectrometry (MS): principles, quadrupole, mass analyzers, timescale of events in MS, quasi equilibrium theory (QET), unimolecular dissociations in MS, mass spectrum and isotopes, data dependent MS/MS, targeted MS/MS (SID-MRM-MS), protein identification: N-terminal sequencing, MALDI –TOF, LC-MS/MS, Tandem-MS/MS. SELDI-TOF, ICAT, I TRAQ (4-plex, 8-plex), MUDPIT, Protein interaction maps, analysis of cellular constituents, metabolomics, functional proteomics; Clinical and biomedical application of proteomics; Proteome database		**12**	**0**	**0**
Module 3: Protein design and engineering- components, methods, and tools				
Molecular scaffolds: Repeat proteins like tetratricopeptide repeats (TPRs), ankyrin repeats (ANKs), leucine-rich repeats (LRRs), armadillo repeats (ARMs), and hexapeptide repeats (HPRs) for diagnostics and PPI studies, artificial protein design, *de novo* protein design (ROSETTA), Antibody engineering, Protein chips		**8**	**0**	**0**
Module 4: Structure function data on proteins				
Structural and functional information through X-ray crystallography, NMR, Electron Microscopy, computational techniques		**8**	**0**	**0**
Module 5: Engineered protein applications				
Peptidomimetics (common intermediate, solid phase synthesis and combinatorial approaches), stimulus responsive peptide systems, biosensors, drug delivery,		**7**	**0**	**0**

nanodevices and tissue engineering (biopolymers), microbial proteins (dairy, pharmaceutical, industrial, and environmental units)			
Total	**45**	**0**	**0**

Evaluation criteria:
1. Minor test 1 30%
2. Minor test 2 30%
3. Major test (end semester) 40%

Learning outcomes:
1. Able to gain understanding of protein separation and synthesis methods. (Test 1)
2. Acquire a deep insight into the tools and techniques of proteomics with special emphasis on mass spectrometric methods. (Test 1 and Test 2)
3. An understanding of various design strategies of proteins. (Test 2)
4. Able to apprehend the structure function relationship of proteins through three-dimensional structural analysis. (Test 2 and Test 3)
5. Able to grasp applications of engineered proteins. (Test 3)

Pedagogical Approach:
1. Lectures and tutorials, demonstration of online resources.
2. Providing case studies to support the concepts.
3. Peer-reviewed research articles to discuss various modules in the course.

Skill Set:
1. Knowledge of protein separation techniques.
2. Knowledge of tools employed in mass spectrometry, applications and, how to characterize a proteome.
3. Knowledge of methods to design artificial protein scaffolds and applications.

Employability:
The course will provide skillsets and knowledge that may play a key role to get employed in Universities, R & D industries, Medical centres/Colleges, Research Institutes and Diagnostic centres apart from specialized units like pharma, breweries, dairy and agri sectors.

Materials:
Suggested Readings

1. Radziwon K, Weeks AM. Protein engineering for selective proteomics. Curr Opin Chem Biol. 2021 Feb;60:10-19. doi: 10.1016/j.cbpa.2020.07.003. Epub 2020 Aug 5. PMID: 32768891.
2. Cattaneo A, Chirichella M. Targeting the Post-translational Proteome with Intrabodies. Trends Biotechnol. 2019 Jun;37(6):578-591. doi: 10.1016/j.tibtech.2018.11.009. Epub 2018 Dec 18. PMID: 30577991.
3. Černý M, Skalák J, Cerna H, Brzobohatý B. Advances in purification and separation of posttranslationally modified proteins. J Proteomics. 2013 Oct 30;92:2-27. doi: 10.1016/j.jprot.2013.05.040. Epub 2013 Jun 15. PMID: 23777897.
4. Yakubu RR, Nieves E, Weiss LM. The Methods Employed in Mass Spectrometric Analysis of Posttranslational Modifications (PTMs) and Protein-Protein Interactions (PPIs). Adv Exp Med Biol. 2019;1140:169-198. doi: 10.1007/978-3-030-15950-4_10. PMID: 31347048; PMCID: PMC7059822.
5. Mirza SP, Olivier M. Methods and approaches for the comprehensive characterization and quantification of cellular proteomes using mass spectrometry. Physiol Genomics. 2008 Mar 14;33(1):3-11. doi: 10.1152/physiolgenomics.00292.2007. Epub 2007 Dec 27. PMID: 18162499; PMCID: PMC2771641.
6. Sawyer N, Gassaway BM, Haimovich AD, Isaacs FJ, Rinehart J, Regan L. Designed phosphoprotein recognition in Escherichia coli. ACS Chem Biol. 2014 Nov 21;9(11):2502-7. doi: 10.1021/cb500658w. Epub 2014 Oct 6. PMID: 25272187; PMCID: PMC4245168.

7. Hansen S, Kiefer JD, Madhurantakam C, Mittl PRE, Plückthun A. Structures of designed armadillo repeat proteins binding to peptides fused to globular domains. Protein Sci. 2017 Oct;26(10):1942-1952. doi: 10.1002/pro.3229. Epub 2017 Jul 25. PMID: 28691351; PMCID: PMC5606530.
8. Hansen S, Tremmel D, Madhurantakam C, Reichen C, Mittl PR, Plückthun A. Structure and Energetic Contributions of a Designed Modular Peptide-Binding Protein with Picomolar Affinity. J Am Chem Soc. 2016 Mar 16;138(10):3526-32. doi: 10.1021/jacs.6b00099. Epub 2016 Mar 2. PMID: 26878586.
9. Ernst P, Plückthun A. Advances in the design and engineering of peptide-binding repeat proteins. Biol Chem. 2017 Jan 1;398(1):23-29. doi: 10.1515/hsz-2016-0233. PMID: 27636831.
10. Parmeggiani F, Huang PS. Designing repeat proteins: a modular approach to protein design. Curr Opin Struct Biol. 2017 Aug;45:116-123. doi: 10.1016/j.sbi.2017.02.001. Epub 2017 Mar 3. PMID: 28267654.
11. Javadi Y, Itzhaki LS. Tandem-repeat proteins: regularity plus modularity equals design-ability. Curr Opin Struct Biol. 2013 Aug;23(4):622-31. doi: 10.1016/j.sbi.2013.06.011. Epub 2013 Jul 4. PMID: 23831287.
12. Wei R, von Haugwitz G, Pfaff L, Mican J, Badenhorst CPS, Liu W, Weber G, Austin HP, Bednar D, Damborsky J, Bornscheuer UT. Mechanism-Based Design of Efficient PET Hydrolases. ACS Catal. 2022 Mar 18;12(6):3382-3396. doi: 10.1021/acscatal.1c05856. Epub 2022 Feb 28. PMID: 35368328; PMCID: PMC8939324.
13. Samak NA, Jia Y, Sharshar MM, Mu T, Yang M, Peh S, Xing J. Recent advances in biocatalysts engineering for polyethylene terephthalate plastic waste green recycling. Environ Int. 2020 Dec;145:106144. doi: 10.1016/j.envint.2020.106144. Epub 2020 Sep 25. PMID: 32987219.
14. Jisna VA, Jayaraj PB. Protein Structure Prediction: Conventional and Deep Learning Perspectives. Protein J. 2021 Aug;40(4):522-544. doi: 10.1007/s10930-021-10003-y. Epub 2021 May 28. PMID: 34050498.
15. Zhang Y. Protein structure prediction: when is it useful? Curr Opin Struct Biol. 2009 Apr;19(2):145-55. doi: 10.1016/j.sbi.2009.02.005. Epub 2009 Mar 25. PMID: 19327982; PMCID: PMC2673339.

Additional information (if any): The course framework and modules were designed and conceptualized by Dr. Chaithanya Madhurantakam. Further inputs were received from Dr. Pooja Anjali Mazumdar (PhD, IIT KGP), Independent Investigator, New Delhi.

Student responsibilities:

2. Study of course material as specified by the instructor.

Course Reviewers:

1. Dr. Peer Mittl, Senior Scientist, Department of Biochemistry, University of Zurich, Switzerland
2. Dr. Nidhi Pareek, Associate Professor, Deptt. of Sports Bioscience, School of Sports Sciences, Central University of Rajasthan, Bandarsindri, N.H. 8, Kishangarh, Ajmer - 305 817, Rajasthan, India.

Course title: Bioethics, IPR and Regulations in Biotechnology			
Course code:	**No. of credits:** 3	**L-T-P:** 39-6-0	**Learning hours: 45**
Pre-requisite course code and title (if any): None			
Faculty:		**Department:** Department of Biotechnology	
Course coordinator(s):		**Course instructor(s):**	
Contact details:			
Course type: Core		**Course offered in:** Semester 3	

Course description:

Ethics encompass the guiding principles to prescribe what is fair and right. It includes components such as values, integrity, morality etc. Considering the impact of modern biology and medical research and its associated socio-economic importance, researchers need to be sensitive to the ethical obligations while designing and conducting research and disseminating research outcomes. On the other hand, the perceptions of the society about the scientific innovations are not uniform. Some consider the innovations as solutions; but there may have concerns as well.

The part A of the present course deals with the ethical issues related to biotechnology. It seeks to sensitize the candidates to wider issues concerning the ethics in biotechnology. The topics include ethics relating to transparency in scientific validation and ownership issues. Further, topics such as stem cell transplantation, xeno-transplantation and the impact of rDNA-based medicines on the public morality would be discussed. The importance of effective communication strategies is also covered.

The part B deals with the intellectual property rights and regulatory issues related to biotechnology. The course includes various regulations, national and international, and treaties related to biological processes, research and materials.

Course objectives:

1. Creating awareness among the students about ethics in research
2. Imparting knowledge about the relevant national laws and regulations related to biotechnological research and their products
3. Providing knowledge about different kinds of IPRs with especial reference to biotechnological research

Course contents

Module		L	T	P
	Part A: Bioethics	**10**		
1	**Overview of Bioethics and ethical issues in biotechnology** Socio-economic issues and broader impact on society Transparency and scientific validation on regulatory procedures Research priorities and ownership issues	5		
2	**Public Awareness and communication strategies** Bioethics involved in experimental animals and clinical research. Developing effective communication strategies Dissemination of scientific information effectively in common language	5		
	Part B: IPR and Regulations in Biotechnology	**29**	**6**	
3	**Principles and Perspectives on Biotechnology Regulation**	**7**		
	Introduction to legal framework Constitution, Statutes, Rules, Regulations, Judicial System, Administrative set up. International Law, Sources, Treaties Principles of Biotechnology Regulation: Risk Assessment, Risk Management and Risk Communication. Precautionary principle and precautionary approach			

	Country Comparisons on perspectives and approaches to Biotechnology Regulations The U.S. and E.U. approaches on Biotechnology research, Intentional introduction into environment, GM Food, labelling etc.			
4	**International framework for Biotechnology**	6		
	Multilateral Agreements: Convention on Biological Diversity, Cartagena Protocol on Biosafety, WTO Agreements, Codex Alimentarius, Plant Genetic Resources for Food and Agriculture. Judicial response to disputes on biotechnology trade and development			
5	**Regulatory Systems in India**	8	2	
	Environment Protection Act, 1986 Rules for the manufacture, use, import, export and storage of hazardous micro- organisms, genetically engineered organisms or cells, 1989 Institutional Structure, Powers and Functions Relevant Guidelines and Protocols. Other relevant laws The Biological Diversity Act, 2002 Protection of Plant Varieties and Farmer's Rights Act, 2001 Drugs and Cosmetics Act, Policy and the rules Seed Policy DGFT Notification Recent Initiatives Draft National Biotechnology Regulatory Bill 2013			
6	**Intellectual Property Rights**	8	4	
	Introduction A Brief history of IP protection TRIPS, Biotechnology and IPR Rationale for IPR Types of IPRs Patents, Copyright, Trademarks, Trade Secrets, Plant Variety protection, Geographical Indications, Farmer's Rights, Traditional Knowledge **Biotechnology Innovation and IPR** Choice of IP Patentability criteria Relevant Case law Patent protection of biotechnology in US, EU and Indian Patent Act, 1970			
	Total	**39**	**6**	

Evaluation criteria:
1. Assignment: 30%
2. Minor test: 20%
3. Major: 50%

Learning outcomes: Upon completion of this course the students will have an;
1. Awareness about ethics in research (Modules 1-2)
2. Understanding about current laws and regulations related to biodiversity and biotechnology (Modules 3-5)
3. Understanding about IPRs related to biotechnological research (Module 6)

Pedagogical Approach:
Lectures and tutorials supported by critical appraisal of original research articles, reviews, books and book chapters, hands-on-training and demonstration of online resources

Skill Set:
1. Students will have knowledge about the IPR related to agriculture and medical biotechnology.
2. Students become able to draft the application for patents, design registration, copyrights, and others.

Employability:
1. Law firms and knowledge processing organizations, IP management consultancy
2. Regulatory bodies and funding agencies
3. Medical biotechnology, Agri-biotechnology, agri-genomics and seed companies

Materials:

Suggested readings (Representative)

1. Sreenivasulu N.S. (2016)., Law relating to biotechnology, Oxford University Press, New Delhi.
2. K.D. Raju (ed.) (2007), Genetically modified organisms: Emerging law and policy in India, TERI, New Delhi
3. P. Narayan (2001), Patent Law, 3rd edn., Eastern Law House, Calcutta
4. Kamala Sankaran and Ujjwal Kumar Singh (eds.) (2008), Towards legal literacy: An introduction to Law in India, Oxford, New Delhi
5. W.R. Cornish (1999)., Intellectual Property, 4th edn., Sweet & Maxwell, London,
6. Jayashree Watal(2001)., Intellectual Property Rights in the WTO and Developing Countries, Oxford, New Delhi,
7. F.H. Erbisch and K.M. Maredia (Eds.) (2004)., Intellectual Property Rights in Agricultural Biotechnology, 2nd edn., CABI Publishing, Oxon
8. Charles Mc Mannis (ed.) (2007), Biodiversity and the Law, Earthscan, London.
9. Report of the Task Force on Application of Agricultural Biotechnology, Ministry of Agriculture, Government of India, (2004).
10. National Biotechnology Development Strategy (Draft), Department of Biotechnology, Ministry of Science and Technology, Government of India.
11. Shyam Divan and Armin Rosencranz (2005), Environmental Law and Policy in India, 2nd edn., Oxford, New Delhi. Ch.4

Required texts:
Research articles, reviews on relevant topics, websites and relevant links as provided by the instructor in lectures and tutorials

Student responsibilities:
1. Class attendance
2. Study of course materials as specified by the instructor
3. Self-study

Course Reviewers:
1. Dr. Zubair Ahmed Khan, Department of Law, Guru Gobind Singh Indraprastha University, Delhi
2. Professor Havagiray R. Chitme, Professor of Pharmacology and Head, IPR Cell, DIT University, Dehradun, India

Course title: Biotechnology laboratory – Part 3						
Course code: BBP 107	**No. of credits:** 7	**L-T-P:** (0-0-210)	**Learning hours:** 210			
Pre-requisite course code and title (if any): None						
Department: Department of Biotechnology						
Course coordinator:	**Course instructor:**					
Contact details:						
Course type: Core	**Course offered in:** Semester 3					
Course description: The objective of this laboratory course is to introduce students to experiments related to biotechnology. The course is designed to teach students the utility of various experimental methods in biotechnology in a problem-oriented manner. The list of experiments given in each module is representative and includes experiments. Part A will be common for both the streams. Part B1 is only for Microbial Biotechnology stream whereas Part B2 is only for Plant Biotechnology stream. The instructor may choose experiments for student's laboratory training as per requirements.						
Course objectives: 1. To provide training on standard as well as advanced techniques in the field of molecular biology, biochemistry, microbiology and plant biology. 2. To introduce the students to various techniques of bioinformatics used to analyze DNA, RNA and protein sequences 3. To train the students in designing experiments with appropriate controls.						
Course contents						
Module	**Topic**			**L**	**T**	**P**
Suggested experiments						
	PART A: Common to both streams					150
	1. Searching sequences with BLAST in GenBank (NCBI) database 2. Multiple sequence alignment using ClustalW/MUSCLE 3. Phylogenetic analysis of proteins and DNA sequences using MEGA 4. Processing of fastq files by FastQC/FastP/FastX/Trimmomatic for quality, trimming etc. 5. Formatting of data files on Galaxy platform 6. Designing of PCR primers with Primer2/Batchprimer3 7. Homology modelling of proteins 8. Analysis of molecular data using Corehunter or PowerCore-Core collections 9. Genotyping of mapping populations with codominant markers 10. Analysis of marker segregation and Chi-square test 11. Construction of linkage map from SNP data using JoinMap 12. QTL mapping in mapping populations using SNP marker data 13. Analysis of GWAS using SNP data 14. Protein Separation Techniques- Purification of target protein using IMAC 15. Protein Separation Techniques- Purification of target protein using Ion Exchange Chromatography-I 16. Protein Separation Techniques- Purification of target protein using Ion Exchange Chromatography-II 17. Protein Separation Techniques- Purification of target protein using Gel Exclusion Chromatography-I					

	18. Protein Separation Techniques- Purification of target protein using Gel Exclusion Chromatography-II 19. Analysis of purified protein through SDS PAGE and quantification of purified protein 20. Salting out method to purify a recombinant target protein 21. Packing the chromatographic column for protein purification method			
	PART B1: Microbial Biotechnology			60
	1. Isolation of endophytic bacteria from different plants 2. Isolation of microbes from soil and rhizosphere 3. 18S rRNA/ ITS sequencing for identification of fungal isolates 4. In-silico analysis: Identification of binding cavity on the surface of a pathogenic protein and docking with potential ligands-I 5. In-silico analysis: Identification of binding cavity on the surface of a pathogenic protein and docking with potential ligands-II 6. In-silico analysis: Analysis of protein-antibody complex			
	PART B2: Plant Biotechnology			60
	1. Designing of primers for miRNA quantification 2. Designing of guide RNA for CRISPR/Cas9 genome editing 3. Pollen viability testing by staining and pollen germination 4. Emasculation and controlled crosses to develop F1 hybrids 5. Screening for disease resistance (Viral, bacterial, and fungal) in plants 6. Screening for salt/ heavy metal tolerance in plants 7. Analysis of morphological data with ImageJ software			

Evaluation criteria:

1. Attendance: 5%
2. Preparation of lab record(s) throughout the semester: 25%
3. End semester evaluation: 70% (Following components would be included)
   a) Spotting: 15 %
   b) Viva-voce: 15 %
   c) Experiment(s) assigned on the day of the exam: 40%

Learning outcomes:

1. Ability to conduct experiments with adequate safety precautions.
2. Capacity to compare and evaluate various approaches in solving a given experimental problem.
3. Ability to design and interpret molecular biology experiments.
4. Designing experiments with critical thinking, creativity and using a problem-solving approach
5. Proficiency in defining a research problem, drawing logical inferences from results and documenting outcomes in systematic manner.

Pedagogical Approach: Wet lab experiments, demonstrations, calculations, computer based analytical methods used in analysis of DNA, RNA and protein data, writing of experimental results and analysis report, visits to different research facilities.

Skill Set:

1. Able to work in biotechnology lab and perform experiments
2. Able to analyses experimental data and critical thinking.

Employability:

1. Academic and industrial research
2. Industries based on biotechnology, pharmacy, and agriculture.

Materials-

1. Study material and laboratory protocol will be provided by course instructor.

2. “Biochemistry Laboratory: Modern Theory and Techniques” Rodney Boyer, second Edition, Pearson Education, 2012.
3. “Analytical Techniques in Biochemistry and Molecular Biology” Rajan Katoch, Springer, 2011.
4. “DNA and protein sequence analysis. A Practical approach” Bishop M.J., Rawlings C.J. (Eds.)1997.

Website

1. https://nptel.ac.in/

Journals

1. Peer reviewed relevant scientific journals.

Advanced Reading Material

Will be provided by instructor if require.

Additional information (if any)

List of experiments given in each module are representative, instructor may choose any of them for student’s laboratory training as per requirements.

Student responsibilities

1. Class attendance.
2. Study of course materials as specified by the instructor.
3. Regular submission of given class assignments.

Reviewers

1. Professor Bijoy Neog, Professor, Department of Life Sciences, Dibrugarh University, Assam
2. Dr. Tapan K Mondal, Principal Scientist, ICAR-NIPB, Pusa Campus, New Delhi
3. Dr. Rupesh Deshmukh, Associate Professor, Plaksha University, Mohali, Punjab

Programme structure						
Semester	**Course No.**	**Course Title**	**Type**	**Number of Credits**	**No. of L-T-P**	**Course Coordinator**
Semester 1	NRE 113	Applied mathematics	Core	0	33-12-0	Dr Montu Bose
Semester 1	BBP 111	Bioanalytical techniques	Core	3	39-6-0	Dr Udit Soni
Semester 1	BBP 174	Bioinformatics and computational biology - Part I	Core	2	22-8-0	Dr Mohammad Zeeshan Ansari
Semester 1	BBP 105	Biotechnology laboratory - Part 1	Core	7	7-0-196	Prof Ramakrishnan Sitaraman
Semester 1	NRE 106	Communication Skills and Technical Writing	Core	0	16-14-0	Dr Suneel Deambi
Semester 1	BBP 158	Conceptual foundations of molecular biology	Core	2	30-0-0	Prof Ramakrishnan Sitaraman
Semester 1	BBP 123	Plant and Animal Biotechnology	Core	2	30-0-0	Dr Shashi Bhushan Tripathi
Semester 1	BBP 161	Principles of Biochemistry and Biophysics	Core	2	30-0-0	Dr Chaithanya Madhurantakam
Semester 1	BBP 155	Principles of genetic engineering and recombinant DNA technology	Core	3	30-15-0	Prof Anandita Singh
Semester 2	BBP 106	Biotechnology Laboratory - Part 2	Core	7	0-0-210	Prof Anandita Singh
Semester 2	BBP 144	Conservation Genetics and Genomics	Core	2	30-0-0	Dr Shashi Bhushan Tripathi
Semester 2	BBP 146	Genome Structure and Diversity: Concepts and Methodologies	Core	3	23-22-0	Prof Anandita Singh
Semester 2	BBP 115	Introduction to Nanobiotechnology	Core	2	22-8-0	Dr Udit Soni
Semester 2	BBP 145	Microbial Pathogenesis	PE	2	15-15-0	Prof Ramakrishnan Sitaraman
Semester 2	BBP 114	Molecular Cell Biology - From Genes to Communities	Core	2	30-0-0	Prof Ramakrishnan Sitaraman
Semester 2	BBP 131	Molecular Microbiology and Immunology	Core	2	30-0-0	Dr Chaithanya Madhurantakam
Semester 2	BBP 116	Molecular Plant Physiology and Metabolism	PE	2	30-0-0	Dr Shashi Bhushan Tripathi
Semester 2	BBP 112	Statistics for The Life Sciences	Core	3	30-15-0	Dr Montu Bose
Semester 3	BBP 141	Bioethics, IPR and Regulations in Biotechnology	Core	3	39-6-0	Dr Vidhi M Chadda
Semester 3	BBP 162	Bioprocess Engineering and Environmental Biotechnology	PE	3	30-15-0	Dr Chaithanya Madhurantakam
Semester 3	BBP 103	Biotechnology Laboratory - Part 3	Core	7	0-0-210	Dr Chaithanya Madhurantakam
Semester 3	BBP 147	Molecular Genetics for Plant Functional Genomics: Principles and Practice	PE	3	22-23-0	Prof Anandita Singh
Semester 3	BBP 163	Gene Expression Analysis and Transcriptomics	Core	2	30-0-0	Prof Ramakrishnan Sitaraman
Semester 3	BBP 164	Proteomics and Protein Engineering	Core	3	45-0-0	Dr Chaithanya Madhurantakam
Semester 4	BBP 108	Major project	Core	16	0-0-672	Prof Ramakrishnan Sitaraman

Total credits: 78