Savitribai Phule Pune University, Pune

(Formerly University of Pune)

New Syllabus of Ph.D. Course Work in Biochemistry

Board of Studies in Chemistry

Savitribai Phule Pune University, Pune

Course List for Ph.D. course work in Biochemistry

Sr. No.	Name of the Course	Credits	No. of Hours
1	**Research Methodology Theory**	**04**	**60**
2	**Subject specific advanced level courses** Compulsory Course Advanced Tools and Techniques in Biochemistry Research	**04**	**60**
3	**Select <u>any One</u> courses from the following:** 1. Molecular and Computational Tools in Biochemistry Research 2. Protein Science and Engineering 3. Advanced Techniques in Plant Biochemistry and Biotechnology 4. Proteins and Enzyme Technology 5. Genetic Engineering	**04**	**60**

Biochemistry Ph.D. Course work

Syllabus

Research Methodology

Credits: 4

Hours: 60

Type: Theory

Course Outcomes

- CO1: Recall the fundamental concepts, objectives, and ethical principles of scientific research, including types of research, plagiarism, and intellectual property rights.
- CO2: Explain different sources of scientific literature, search databases, and types of research publications along with their structural components and ethical standards. (Covers Units 2 & 3)
- CO3: Apply appropriate search strategies, referencing methods, and plagiarism-checking tools to identify research gaps and develop research hypotheses.
- CO4: Analyze chemical data using statistical and computational tools and interpret results through graphical and numerical analysis.

- CO5: Evaluate research quality using journal and author metrics, statistical validation, and ethical guidelines to ensure reliability and scientific integrity.
- CO6: Design and develop a complete research proposal or publication by integrating hypothesis formulation, data interpretation, budgeting, and effective presentation skills.

Content

Unit 1: Introduction to Research (10 hrs)

Meaning & Objectives of Research, Scientific Method and Types of Research: Fundamental(Basic) vs. Applied, Qualitative vs. Quantitative, Experimental vs. Theoretical/ Computational, Research Process & Problem Identification: Literature survey, hypothesis formulation, research gaps, Ethics in Research: Plagiarism, authorship, data fabrication, misconduct (case studies), Intellectual Property Rights (IPR) & Patents: Basics of patents, copyrights, trademarks

Unit 2: Literature Review and Research Ethics (10 hrs)

Scientific Literature Sources: Primary, secondary, tertiary (journals, books, patents, databases), Search Strategies & Databases: SciFinder, Reaxys, Web of Science, Scopus, Google Scholar, Research ethics: plagiarism issues, tools (Turnitin, iThenticate, etc.)

Unit 3: Types of Articles and Research Metrics (10 hrs)

Types of Technical Documents: full-length papers, short communications, letters, reviews, monographs, book chapters, theses, conference proceedings, Components of a Research Publication: title, abstract, aims/objectives, hypothesis, rationale, methodology, results & discussion, key issues, acknowledgments, conflict of interest, bibliography, Research Metrics: Journal metrics: Impact Factor (JCR), SNIP, SJR, IPP, CiteScore, Author metrics: h-index, gindex, i10-index

Unit 4: Data Analysis Using Chemistry Software and Statistical Tools (10 hrs)

Statistical Tools for Chemical Data Analysis: Descriptive statistics: mean, median, mode, standard deviation, variance, Correlation and regression analysis (linear, multiple), Analysis of Variance (ANOVA) for comparing datasets, Significance testing: t-test, χ^2 test, F-test, p-values, Error analysis: accuracy, precision, propagation of error, confidence limits,

Unit 5: Scientific Communication: (20 hrs)

Importance of scientific communication. Types of scientific communications.

Different modes of scientific communication: Scientific Writing: Characteristics of good scientific writing, structure and content, style, literature references, Bibliography.

Report Writing: Types of research reports, guidelines for writing a report, report format. Details of research proposal writing. Research paper writing (IMRAD format). Thesis writing.
Oral forms of scientific Communication: Popular and scientific talks, poster presentations, organizing presentation material, use of audiovisual aids in presentation, elements of presentation preparation: objective, subject, audience, length of talk managing and delivering presentations.

References

1. C.R. Kothari & Gaurav Garg, Research Methodology: Methods and Techniques, New Age International.
2. J.W. Creswell & J.D. Creswell, Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, SAGE.
3. D.C. Montgomery, Design and Analysis of Experiments, Wiley.
2. World Intellectual Property Organization (WIPO) – Patent & IPR Guidelines (official website).- https://www.wipo.int/portal/en/index.html
3. IP Government of India- https://ipindia.gov.in/
4. ACS (American Chemical Society) Publications – Author & Reviewer Resource Center.
5. RSC (Royal Society of Chemistry) Publishing – Guide for Authors.
6. Elsevier Author Hub – Researcher Academy (online).
7. Robert A. Day & Barbara Gastel, How to Write and Publish a Scientific Paper, Cambridge University Press
8. Silvia, Paul J., How to Write a Lot: A Practical Guide to Productive Academic Writing, APA.
9. DST, ANRF, CSIR – Funding Guidelines and Proposal Formats (official websites).
10. Origin / OriginPro – https://www.originlab.com/
11. Mnova (Mestrelab Research) – https://mestrelab.com/
12. SwissADME – Web tool access- http://www.swissadme.ch/index.php
13. GROMACS – https://www.gromacs.org/index.html
14. Gaussian – Official site (licensed)- https://gaussian.com/
15. ORCA Quantum Chemistry Package – https://orcaforum.kofo.mpg.de/index.php
16. GAMESS (US version) – https://www.msg.chem.iastate.edu/gamess/
17. Gabedit (GUI for QC codes) – https://gabedit.sourceforge.net/

BIOCHEMISTRY

Compulsory Course: Advanced Tools and Techniques in Biochemistry Research (credits-4, 60 h)

Course Outcomes:

- **CO1:** Demonstrate the ability to analyse and separate biomolecules such as carbohydrates, lipids, amino acids, and proteins using modern biochemical methods. Explain the principles and applications of analytical biochemical techniques, including chromatography, electrophoresis, spectroscopy, and microscopy.
- **CO2:** Learn the microbial cells and animal tissue culture techniques, Demonstrate the principles and techniques of plant tissue culture.
- **CO3:** Learn modern biochemical, molecular, and computational techniques for interpreting molecular evolution, homology modelling, molecular docking, and computer aided interaction to predict protein and nucleic-acid behaviour.
- **CO4**: Students will understand the databases available in the field of Bioinformatics and their applications in the field of Bioinformatics, Biomedical research, etc.

Course Content:

Unit 1 Biomolecules Separation, identification and characterization tools: (20 h)

a. Chromatography techniques: gel filtration, Ion exchange, affinity, TLC, HPLC, FPLC, HPTLC, GC, LC, Mass Spectroscopy (MALDI-TOF) and Preparative techniques.
b. Analytical tools: Spectroscopy techniques - UV-Vis, Fluorescence, CD, FTIR, NMR, IR, ESR, X-ray crystallography, ELISA, SPR. Microscopy-;
c. Gel Electrophoresis - (Agarose and PAGE), 2 D electrophoresis, Blotting techniques, Immunoprecipitation.
d. Microscopic techniques - FACS and MACS, phase-contrast, super-resolution, light, fluorescence, SEM, TEM, Confocal, electron microscopy.

Unit II: Culture techniques and its application in bioactive components identification and characterization: (20 h)

Microbial culture:

a. Cell structure and components, isolation, characterization and identification of microorganisms
b. Optimization of nutrition, physiology and growth of microbial cells, reproduction and growth.
c. Preparation of consortium (bacteria, fungus and virus) for various applications.
d. Production of mutants by chemical and physical agents and their characterizations.

Animal tissue culture:

a. Advantages of tissue culture, Primary Cell Culture: Initiation of a primary cell culture, cell lines, subculture and maintenance of cell line, Differential culture media. Adherent and Suspension tissue culture, Organ culture and Stem cell Culture, 3D culture, Cell and tissue banking,
b. Cross-contamination and Misidentification: Mycoplasma, bacterial, yeast, viruses cross-contamination and Misidentification, naming a cell line, Routine Maintenance, Significance of Cell Morphology, Choosing a Cell Line, viable cell count, antibiotic free stock culture
c. Cell fusion methods: Techniques involved in cell fusion, Hybridoma cells: definition; preparation; properties and use of hybridoma technology.
d. Methods of cell preservation, Cytotoxicity assays and its applications

Plant tissue culture:

a. Culture methods, media preparations, callus, meristem and organ culture, plant regeneration, protoplast fusion, cybrids, somatic embryogenesis, somoclonal selection and micropropagation in plants, which are required for pharmaceutical. and nutraceutical research and in personalized medicine, drug discovery and development

Unit III: Bioinformatics and Biostatistics tools: **(20 h)**

Fundamentals of Bioinformatics:

a. Introduction to bioinformatics; Concept of databases; Types of biological databases: Primary/Genomic and Composite Databases; Literature Databases: Open access and open sources, PubMed, PLoS, Biomed Central, NAR databases;
b. Pairwise sequence comparisons programming; Global and local alignments; Measures of sequence similarity (Alignment score, % sequence identity; percentage similarity; statistical scores, E, P and Z); Experiential approaches for database searching; BLAST and FASTA; multiple sequence alignment; SP scoring; multidimensional dynamic programming; progressive sequence alignment approach.
c. Protein Sequence Databases: Different type of protein database and its formats and files.
d. Structure and derived databases: Primary and Secondary structure databases: Structural Classification of Proteins, Class Architecture Topology Homology, Families of Structurally Similar Proteins,
e. Catalytic Site Atlas CSA; Molecular functions/Enzymatic catalysis database; Protein-Protein interaction database: Chemical Structure database; Gene Expression database.

Applications of Bioinformatics: Gene, ORF of a gene, promoter and regulatory elements prediction; phylogenetic analysis (phylogeny, Phylogenetic tree, construction methods of Phylogenetic tree and Phylogenetic programs).

Fundamentals of Statistics: Arithmetic mean, median, mode: measures of variation: standard deviation, variance, coefficient of variation; properties; correlation: types and methods; simple, multiple, linear and nonlinear correlation, Spearman's correlation (ρ or r_s), rank correlation; Regression: linear and curvilinear regression (for X and Y only), regression lines by least square method, regression equations of X on Y and Yon X only; sample size; power of study.

Tests of Significance: Null hypothesis; standard error; level of significance; degrees of freedom; significance of mean for large samples; significance in means for small samples (students t-test); significance in ratio of two samples; F test (for difference between variance of two samples); chi square test; analysis of variance (ANOVA) test for one- and two-way classification; applications of various online tools: SPSS, Minitab, XLSTAT etc.

References:

1. Culture of Animal Cell: R. I. Freshney (Wiley-Liss)
2. Ashok Pandey, Colin Webb, Carlos Ricardo Soccol, Christian Larroche (eds.). Enzyme Technology Springer, 2006

2. Karl-Erich Jaeger, Andreas Liese, Christoph Syldatk (eds.). Introduction to Enzyme Technology Springer Cham, 2024.
3. Khan, M. Y., Khan, Farha (2022). Principles of Enzyme Technology, PHI Learning Private Limited, Delhi.
4. Animal Cell Culture-Practical Approach: R. W. Jhon (Masters Oxford)
5. Biotechnology: U. Satyanarayana (Books & allied Pvt. Ltd.)
6. Principle and practice of Animal tissue culture by Sudha Gangal, 2nd edition (2010).
7. Plant cell tissue and Organ culture by Gamborg Phillips (1995).
8. Plant tissue culture basic and applied T B Jhaand B Gosh (2005)
9. Plant Cell and Tissue Culture, S. Narayanaswamy, Tata McGraw-Hill Publishing Company, 1994, 0074602772.
10. Introduction to plant tissue culture - Course – NPTEL 2021 - https://nptel.ac.in/courses/102103016.
11. Gallery of Medicinal Plants (Dravyaguna Vigyan) Monika Sharma (2020). 1st Edition, Thieme Publishers, India.
12. Introduction to plant tissue culture-Course-NPTEL 2021 https://nptel.ac.in/courses/102103016.
13. Bioinformatics- A Practical Guide to the Analysis of Genes and Proteins by Baxevanis, Andreas D. Baxevanis and B. F. Francis Ouellette, Wiley India Pvt Ltd. 2009
14. Essential Bioinformatics by Jin Xiong, Cambridge University press, New York. 2006
15. Bioinformatics: Sequence and Genome Analysis by Mount D., Cold Spring Harbor Laboratory Press, New York. 2004
16. Introduction to bioinformatics by Teresa K. Attwood, David J. Parry-Smith. Pearson Education. 1999 Old editions

OPTIONAL COURSES (SELECT ANY ONE)

Course 1: Molecular and Computational Tools in Biochemistry Research

Credits: 4

Hours: 60

Type: Theory

Course Objectives

- **CO1**. Provide advanced understanding of experimental and computational techniques used in modern biochemistry and molecular biology.
- **CO2**. Develop skills in analytical, molecular, and computational methodologies for research.
- **CO3**. Train scholars in data analysis, interpretation, and integration of wet-lab and bioinformatic approaches.
- **CO4**: Describe principles behind modern biochemical, molecular, and computational techniques.
- **CO5**: Apply laboratory and bioinformatic tools to solve research problems.
- **CO6**: Interpret experimental and computational datasets for doctoral research.

Content

Unit I: Biochemical & Molecular Techniques (30 Hours)

1. DNA/RNA isolation, PCR, qPCR, RT-PCR.
2. Cloning strategies: restriction–ligation, Gibson, Golden Gate.
3. Gene editing principles: CRISPR-Cas systems.
4. Protein extraction, purification (chromatography), SDS-PAGE, Western blot.
5. Enzyme assays, spectroscopic and chromatographic analytical methods.
6. Interaction assays: ELISA, Co-IP, EMSA.
7. Principles of microscopy and flow cytometry.

Unit II: Computational Biology (30 Hours)

1. **Molecular Modelling and Dynamics**

Concepts of three-dimensional structure visualization and molecular simulation. Basic principles of molecular modeling, including coordinate systems and energy minimization. Introduction to molecular mechanics, potential energy functions, and commonly used force fields in biomolecular modeling.

2. **Molecular Modeling and Docking**

   Application of molecular mechanics and quantum mechanics in drug design. Principles of molecular docking and analysis of drug–receptor interactions. Types of docking approaches including rigid docking, flexible docking, and extra-precision docking

3. **Computational Modelling of Biomolecular Structures**

   Computer-based modeling of secondary and tertiary structures of proteins and nucleic acids using sequence data. Applications in enzyme-based and receptor-based rational drug design.

4. **Quantitative Structure–Activity Relationships: Applications**

   Applications of QSAR in drug discovery including Hansch and Free-Wilson analyses, their advantages and limitations, derivation of 2D-QSAR equations, and introduction to 3D-QSAR and contour map analysis.

References

1. Voet D., Voet J.G, Biochemistry 4th Edition., John Wiley and Sons, 2011.
2. Nelson, D. C. and Cox, M.M., Lehninger Principles of Biochemistry, 5th Edition, W. H. Freeman, 2010.
3. Berg J.M., Tymoczko J.L. and Stryer L., Biochemistry. 7th edition, W.H. Freeman and Co. New York, 2011.
4. Molecular biology by Robert F. Weaver McGraw-Hill 4 edition (2007)
5. Advanced molecular biology by R. M. Twyman, (1998)
6. Genes VII by B. Lewin Oxford University Press, Cell Press, London (2000)
7. Computational Chemistry and Molecular Modeling-Principles and Applications by Ramachandran, Deepa and Namboori, 2008, Springer_Verlag. Reference for Unit 1 and 2.
8. Molecular Modeling Principles and Applications (2nd Ed.) by Andrew R. Leach, Prentice Hall, USA. 2001
9. Molecular Modelling for Beginners, (2nd Edition) by Alan Hinchliffe, John Wiley & Sons Ltd. 2008
10. Molecular Modeling and Simulation – An interdisciplinary Guide by Tamar Schlick, Springerverlag. 2000

11. Computational medicinal chemistry for drug discovery edited by Patrick Bultinck, Marcel Dekker Inc. 2004

Course 2: Protein Science and Engineering

Credits: 4

Hours: 60

Type: Theory

Course Outcomes

- **CO1**: Explain the fundamental structural principles of proteins, including amino acid conformations, Ramachandran plots, motifs, and structural families.
- **CO2**: Interpret protein structural organization using schematic/topology diagrams and classify proteins based on α, β, α/β, and small structural families.
- **CO3**: Describe protein folding pathways in prokaryotes and eukaryotes, including the role of chaperones, osmolytes, and mechanisms for recovering active proteins from inclusion bodies.
- **CO4**: Compare folding mechanisms of single-domain and multi-domain proteins and evaluate their biological significance.
- **CO5**: Apply protein engineering strategies such as random mutagenesis, site-directed mutagenesis, gene shuffling, and directed evolution to modify or improve protein function.
- **CO6**: Assess advanced engineering approaches including backbone redesign and antibody engineering using appropriate case studies.
- **CO7:** Utilize computational tools for protein structure prediction, including homology modelling and ab-initio methods, and analyze relationships between sequence, structure, and function.
- **CO8**: Design protein-based applications using phage display systems and structure-based drug design principles, integrating rational protein design approaches.

Content

Unit-I

Protein structural families Introduction; Basic structural principles: amino acids and their conformational accessibilities, Ramachandran Plot; Motifs of protein structures and their packing; Schematic and topology diagrams; Families of protein structures: alpha, alpha/beta, beta, small etc.

Unit-II

Protein folding and assembly Protein folding pathways in prokaryotes and eukaryotes; Single and multiple folding pathways; Protein folding of single domain and multi-domain proteins; Inclusion bodies and recovery of active proteins; Osmolyte assisted protein folding; Structure of chaperones and role of chaperones in protein folding

Unit-III

Protein engineering Strategies for protein engineering; Random and site directed mutagenesis; Various PCR based strategies; Role of low-fidelity enzymes in protein engineering; Gene shuffling and Directed evolution of proteins; Protein backbone changes; Antibody engineering; All topics will deal with case studies.

Unit-IV

Prediction and design of protein structures Similar structure and function of homologous proteins; Role of multiple alignment; Homology and ab-initio method for protein structure prediction; Phage display systems; Structure based drug design and case studies, Rational protein design

References

1. Introduction to Protein structure, 2nd Ed by Carl Branden and John Tooze, Garland Press, 1999.
2. Structure and Mechanism in Protein Science, Alan Fersht, Freeman, 1999.
3. Protein engineering handbook. Edited by Stefan Lutz - Uwe Bornscheuer. Weinheim: Wiley-VCH, 2009. xli, 409-9. ISBN 9783527318506.
4. Protein engineering in Industrial biotechnology, Ed. Lilia Alberghina, Harwood Academic Publishers, 2002.

Course 3: Advanced Techniques in Plant Biochemistry and Biotechnology

Credits: 4

Hours: 60

Type: Theory

Course outcomes

CO1: Explain the pathways of primary and secondary metabolism, including photosynthesis (C3, C4, CAM), respiration, photorespiration, and nitrogen metabolism.

CO2: Analyze the biosynthesis and functional roles of plant primary and secondary metabolites, and its Application in medicinal plant research.

CO3: Evaluate Agrobacterium-mediated gene transfer, the Ti plasmid system, and applications of plant tissue culture engineering in developing transgenic plants with improved traits.

CO4: Assess plant responses to abiotic and biotic stresses and interpret molecular mechanisms underlying stress tolerance using relevant case studies.

CO5: Apply modern biotechnological approaches for generating stress-tolerant plants and improving food safety through physiological and molecular tools.

CO6: Explain and analyze plant–microbe interactions, with emphasis on Plant Growth-Promoting Rhizobacteria (PGPR), their mechanisms, and applications in sustainable agriculture.

CO7: Characterize and bioengineer PGPR for enhanced agricultural productivity and evaluate their industrial applications in agro-biotechnology.

Content

UNIT I

Photosynthesis: CO_2 fixation-CAM, C4, and C3 pathways, photo protective mechanisms, mechanisms of electron transport, light-harvesting complexes. Respiration & Photorespiration: ATP synthesis & plant mitochondrial electron transport, citric acid cycle. Nitrogen Metabolism.

UNIT II

Primary and Secondary metabolites:

Biosynthesis of nitrogenous compounds, phenols, and terpenes & their roles.

Secondary metabolites: definition types, phenolics, flavanoids, lignins, terpenoid, alkaloids, Gum, Pectins and Rubber. Advanced techniques in identification and quantification of metabolites.

Applications in Medicinal plant research: Active principles in medicinal plants and phytochemistry of the metabolites of medicinal importance such as CNS, CVD, Hypo and Hyper glycemic, Hepatoprotective, anti-allergic, anticancer, immunomodulant and role of antioxidants in prevention of diseases.

Unit III

Agrobacterium mediated gene transfer and use of Ti plasmid.

Applications of plant tissue culture engineering, pathogen resistance (BT gene), herbicide tolerance, salt tolerance, production of secondary metabolites and transgenic plants.

Advances in Stress Physiology research: Plant responses to abiotic & biotic stresses. Molecular adaptation and generation of stress tolerant plants. Different case studies. Food safety research.

UNIT IV

Plant biotechnology in improvement of plant microbe interaction. PGPR research: Types and applications in agro industries. Characterization and bioengineering of PGPR.

Advanced farming techniques, Green house, Hydroponics, etc.

References

1. Introduction of Plant Biochemistry, by Goodwin T. W. and E.I. Mercer, Pergamon Press, Oxford, 1983.
2. Plant Physiology, 5th Edition, by Lincoln Taiz and Eduardo Zeiger, Amazon press, 2012
3. Buchanan BB, Gruissem W & Jones RL. 2000. Biochemistry and Molecular Biology of Plants. 2nd Ed. John Wiley.
4. Dey PM &Harborne JB. 1997. Plant Biochemistry. Academic Press.
5. Heldt HS. 1997. Plant Biochemistry and Molecular Biology. Oxford Univ.Press.
6. Mallappa Kumara Swamy, Jayanta Kumar Patra, Gudepalya Renukaiah Rudramurthy (2019).
7. Medicinal Plants: Chemistry, Pharmacology, and Therapeutic Applications, CRC Press, India.

Course 4: Proteins and Enzyme Technology

Credits: 4

Hours: 60

Type: Theory

Course Outcomes

- **CO1**. Understand the structure of proteins and mechanism of action of enzymes.
- **CO2**. Understand the catalytic mechanisms of enzymes.
- **CO3**. Apply the knowledge of enzyme immobilization to produce more products out of it.
- **CO4**. Understanding of enzyme purification by downstream processes and the efficiency testing of enzymes in various solvent systems.
- **CO5**. Apply the knowledge of enzymes gained in medicine and industry
- **CO6**. Handle the sophisticated instruments and clinical analysis of enzymes.

Content

UNIT I: Protein and enzymes (15 L)

Protein structure, functions, compositions and conformation of proteins. Enzyme catalysis- Acid base catalysis, covalent catalysis, an example, serine proteases. Enzyme kinetics – Michaelis Menten equation, Lineweaver Burk plot, Hills equation, Hans plot.

UNIT II: Isolation and purification of enzymes (15 L)

Sources of enzymes for industry, extraction of enzymes for scientific and industrial purposes. Downstream processing of enzymes, uses of soluble enzymes. Study of enzymes in aqueous biphasic systems. Factors affecting the enzyme activity -Substrate concentration, Enzyme concentration, pH, temperature, etc.

UNIT III: Enzyme immobilization and their applications (15 L)

Techniques employed for immobilizing enzymes, kinetics of immobilized enzymes. Advantages and disadvantages in the utilization of soluble enzymes, Immobilized enzymes and immobilized cells. Different types of reactors of immobilized enzymes and their applications.

UNIT IV: Clinical analysis of enzymes (15L)

Application of ELISA and EMIT in clinical analysis. Different types of Biosensors, potentiometric, ampherometric, piezo-electric and immuno biosensors. Electro analytical applications of enzymes, Methods of coenzyme regeneration. Biochips and Biocomputers.

References

1. Dr. Aditya Arya (2018). Understanding Enzymes: An Introductory, S.G. Press.
2. Anil Kumar, Sarika Garg (2017). Enzymes and Enzyme Technology, M.V. Publishers.
3. Khan, M. Y., Khan, Farha (2022). Principles of Enzyme Technology, PHI Learning Private Limited, Delhi.
4. Ashok Pandey, Colin Webb, Carlos Ricardo Soccol, Christian Larroche (eds.). *Enzyme Technology* Springer, 2006
5. Karl-Erich Jaeger, Andreas Liese, Christoph Syldatk (eds.). *Introduction to Enzyme Technology* Springer Cham, 2024.
6. Nikhilesh Kulkarni & Mahindra Deshpande. *General Enzymology* Himalaya Publishing House, (latest ed.)

Course 5: Genetic Engineering

Credits: 4

Hours: 60

Type: Theory

Course Outcomes

- **CO1**: Execute core DNA techniques: Perform nucleic acid isolation, purification, and amplification using various PCR methods (qPCR, RT-PCR, etc.) for genetic analysis.
- **CO2**: Master cloning and expression strategies: Design and implement gene cloning workflows using enzymes and specialized vectors (plasmids, BACs, YACs) to express recombinant proteins in diverse host systems like E. coli, yeast, and plants.
- **CO3**: Apply advanced genome editing: Utilize cutting-edge tools such as CRISPR/Cas9, ZFNs, and TALENs for targeted genome modification, including the creation of transgenic and knockout animal models.
- **CO4**: Analyze "Omics" data: Evaluate large-scale biological data using Next-Generation Sequencing (NGS), microarrays, and mass spectrometry to profile the transcriptome and proteome.

- **CO5**: Evaluate biotechnological applications: Assess the impact of genetic engineering in medicine and agriculture while adhering to biosafety, bioethical guidelines, and intellectual property regulations

UNIT 1: Genetic engineering /Recombinant DNA Technology (30 L)

1. Isolation and purification of nucleic acids
2. Amplification of Nucleic acids: Cloning and PCR
3. Cloning: Basics of cloning, Modifying enzymes like restriction enzymes, polymerases, ligases, phosphatase. Vectors based on plasmid and phages, BAC, YAC, PAC, Expression vectors.
4. Cloning in *E. coli*, yeast, plants (Ti and Ri Plasmid),
5. Selection of clones and Recombinant protein expression and purification in different host systems.
6. PCR: Concept and types of PCR, qPCR, RT-PCR, nested PCR, Asymmetric PCR, applications
7. Principle and applications of southern, northern and western blotting.
8. RNA interference and CRISPR/CAS.
9. Methods of making transgenic and knockout animals, global knockout, conditional knockout, Creloxp and CRISPER/CAS knockout systems.
10. Chromosome engineering, MAGE, Molecular bar codes.

UNIT 2: Genomics, transcriptomics and proteomics (30 L)

1. DNA sequencing: Sequencing genes and genomes: chain termination using dNTPs, pyrosequencing, shotgun and clone contig approaches, chromosome walking, and genetic maps, NGS
2. Whole genome analysis,
3. Construction of genomic and cDNA library
4. Real time PCR to monitor changes in gene expression profile. Microarray- concept of micro arrays, PCR & microRNA array and its application
5. Transcriptomics, epigenomics,
6. Genome editing tools ZFN, TALEN and CRISPR, Anti CRISPR.
7. Protein Engineering: In vitro mutagenesis, Oligonucleotide directed, PCR based, applications of protein engineering
8. Electrophoretic techniques.

References:

1. Daniel L. Hartl & Elizabeth W. Jones: Genetics – Analysis of Genes & Genomes
2. Benjamin A. Pierce: Genetics – A conceptual approach
3. Griffiths, Wessler, Lewontin, Gelbart, Suzuki & Miller: Introduction to Genetic analysis
4. Principles of Gene Manipulation and Genomics by Sandy B. Primrose, Richard Twyman
5. Lewin's GENES XII or any advanced edition
6. Brown T. A. (2020) Gene cloning and DNA Analysis, 8th Edition, Wiley Blackwell Publication, USA.
7. S. B. Primrose and R.M. Twyman - Principles of Genome Analysis and Genomics, 7th Edition, Blackwell Publishing, 2006.
8. S. Sahai - Genomics and Proteomics, Functional and Computational Aspects, Plenum Publication, 1999.
9. Andrezej K Konopka and James C. Crabbe, Compact Hand Book - Computational Biology, Marcel Dekker, USA, 2004.
10. Pennington & Dunn - Proteomics from Protein Sequence to Function, 1st edition, Academic Press, San Diego, 1996.