# Mahayogi Gorakhnath University, Gorakhpur

Faculty of Health and Life Sciences

Department of Biotechnology

Ph.D. Course Work

In

BIOTECHNOLOGY-2025-26

CBCS



Volume No: IV
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**Name of the Program: Pre PhD-Course in Biotechnology**

Program Objectives:

- Enhancing and imparting skills and knowledge in advance research methodologies of biotechnology.
- Solving the existing scientific problems in area of basic and applied biotechnology.
- Creating highly skilled professionals with expertise in current trends of research in area of biotechnology.
- Imparting hands-on experience to students in different techniques and instrumentations of advance biotechnological sciences.
- Generating independent researchers who are capable of translating the research developed at laboratory scale to the industrial level.
- Imparting skills needed to become a successful academician, scientists or inculcating the scientific ethics, temperament to contribute¬entrepreneur to field of science and help in nation building.

**Program Specific outcomes:**

The Students who successfully complete the course will have following skills:

- Solid basic knowledge of research methodologies in area of modern biological sciences specifically applied biotechnology.
- Contributing new methodologies and results in area of the basic and advanced biotechnology for taking the research to the next level.
- Innovative scientists, skilled workforce to work in specialized area of biotechnology.
- Independent researchers who can contribute through fulfilling responsibility of academicians, scientist and entrepreneur.
- Can start an independent research and can contribute in solving new problems faced in current science or in future.
- Develop as a researcher at different research institute at national and international level where they can initiate their independent research.
- Develop skill so that they can be absorbed by R&D, academic or industrial sector of different biotechnological based company/university/institute.

# Ph. D. Biotechnology
## Course Work

| I Year: I Semester | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **S No** | **Course Code** | **Course** | **L** | **T** | **P** | **Evaluation Scheme** | | **Total** | **Credits** | **Course Type** |
| | | | | | | **CIE** | **ESE** | | | |
| **Theory** | | | | | | | | | | |
| 1 | PBT701 | Research Methodology | 4 | 0 | 0 | 30 | 70 | 100 | 4 | Core |
| 3 | PBT703 | Research & Publication Ethics | 2 | 0 | 0 | 30 | 70 | 100 | 2 | Core |
| 5 | …… | Discipline-Specific Courses-1 | 3 | 0 | 0 | 30 | 70 | 100 | 3 | Departmental Elective |
| 6 | …… …… | Open Elective | 3 | 0 | 0 | 30 | 70 | 100 | 3 | Open Elective |
| | | Literature Review Project | | 0 | 2 | 0 | 100 | 100 | 2 | Literature Review |
| **Total** | | | **12** | **0** | **2** | **120** | **380** | **500** | **14** | |

**Elective Course (Any one of the following)**

| Course Nature | Course Code | Courses | Credits |
|---|---|---|---|
| Discipline-Specific Courses | PBT711 | Protein Engineering | 3 |
| | PBT712 | Biomaterials Engineering | 3 |
| | PBT713 | Biofuels & Bioenergy | 3 |
| | PBT714 | Enzyme Engineering | 3 |
| | PBT715 | Pharmaceutical Biotechnology | 3 |
| | PBT716 | Artificial Intelligence in Biological Research | 3 |

**Open Elective Course (Any one of the following)**

| Course Nature | Course Code | Courses | Offer Department |
|---|---|---|---|
| Open Elective Course | PHS 709 | Modern Pharmaceutical Analytical Techniques | Faculty of Pharmaceutical Sciences |
| | PAY 701 | Ayurveda Perspectives of Research Methodology | GGIMS Ayurveda College |
| | PMM 706 | Microbial Metabolism | Department of Medical Microbiology |
| | PBT 722 | Omics Technology | Department of Biotechnology |
| | PMB 722 | Human Metabolic Disorders | Department of Medical Biochemistry |

# Research Methodology
# Code: PBT701

| L | T | P | C |
|---|---|---|---|
| 4 | 0 | 0 | 4 |

**Course objectives (CO)**

1. To introduce the research methodology and nature of problem to be studied and identifying the related area of knowledge.
2. To analyzing the data appropriate to the problem.
3. To reviewing literature to understand how others have approached or deal with the problem.
4. To know the idea of paper and Scientific/ thesis writing.
5. To introduce the funding agencies, databases and research metrics

**Unit I Introduction of Research Methodology and Design**
Meaning, objective, types and significance of research, problems encountered by researchers in India, Need and Features of Good Research Design, Types of Research Designs, Basic Principles of Experimental Designs, Design of experiments, and Synopsis design for research topic.

**Unit II Quantitative Methods**
Tools parametric and non-parametric statistics. Probability, chi square test, t-test, Confidence interval, Errors. Level of significance, Regression and Correlation coefficient, Analysis of variance for one way and two-way classifications, Multiple Comparisons- Least Significant Difference Test, Duncan's new Multiple Range Test, Factorial Analysis, Analysis of Covariance, Use of SPSS.

**Unit III Research Problem, Editing, Data Collection and Validation**
Definition, necessity and techniques of defining research problem, Formulation of research problem, Objectives of research problem.Primary and secondary data, Methods of collecting primary and secondary data, Importance and methods of editing and data validation.

**Unit IV Scientific Writing and Report Generation**
Basic concepts of paper and their writing, literature search, review of literature and peer review, Concepts of Bibliography and References, types of citation, graphical abstracts, significance of report writing, steps of report writing,Research proposal and Types of Research reports and Methods of presentation of report.

**Unit V: Funding Agencies, Databases and Research Metrics**
Funding agencies ICMR, CSIR, DBT-BIRAC, UGC, DST, SERB, ICAR etc. Indexing databases, Citation dataset, web of science, scopus etc. Impact factors of Journal as per citation report, Research Metrics- SNIP, SJR, IPP etc. Metrics: h-index, g-index, i10 index and altmetrics.

**Suggested Readings:**
1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., 2002. An introduction to Research Methodology, RBSA Publishers.

2. Kothari, C.R., 1990. Research Methodology: Methods and Techniques. New Age International. 418p.
3. Sinha, S.C. and Dhiman, A.K., 2002. Research Methodology, EssEss Publications. 2 volumes.
4. Trochim, W.M.K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p.
5. Wadehra, B.L. 2000. Law relating to patents, trademarks, copyright designs and geographical indications. Universal Law Publishing.
6. Anthony, M., Graziano, A.M. and Raulin, M.L., 2009. Research Methods: A Process of Inquiry, Allyn and Bacon.
7. Carlos, C.M., 2000. Intellectual property rights, the WTO and developing countries: the TRIPS agreement and policy options. Zed Books, New York.
8. Coley, S.M. and Scheinberg, C. A., 1990, "Proposal Writing", Sage Publications.
9. Day, R.A., 1992.How to Write and Publish a Scientific Paper, Cambridge University Press.
10. Fink, A., 2009. Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications
11. Leedy, P.D. and Ormrod, J.E., 2004 Practical Research: Planning and Design, Prentice Hall.
12. Satarkar, S.V., 2000. Intellectual property rights and Copy right. EssEss Publications.

**Course Learning Outcomes (CLO):**

On completion of this course, the students will be able to:

1. Understand the limitations of particular research methods.
2. Develop skills in qualitative and quantitative data analysis and presentation.
3. Develop advanced critical scientific thinking skills.
4. Describe the idea of paper and scientific/ thesis writing.

# Research & Publication Ethics
# Code: PBT702

| L | T | P | C |
|---|---|---|---|
| **4** | 0 | **0** | **4** |

**Course Objectives (CO)**

1. To describe philosophy, ethics and scientific conduct.
2. To explain the publication ethics and publication misconduct.
3. To understand open access publication, databases and research metrics

**Unit-I Philosophy, Ethics and Scientific Conduct**
Introduction to philosophy: definition, nature and scope, concept, branches; Ethics: definition, moral philosophy, nature of moral judgements and reactions, Ethics with respect to science and research, intellectual honesty and research integrity, Scientific misconducts: falsification, fabrication and plagiarism (FFP), Redundant publications: duplicate and overlapping publications, salami slicing, Selective reporting and misrepresentation of data, and falsification of images.

**Unit-II Publication Ethics**
Definition, introduction and importance of publication ethics, Best practices/standards setting initiatives and guidelines: COPE, WAME, etc., Conflicts of interest, Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types, Violation of publication ethics, authorship and contributor ship, Identification of publication misconduct, complaints and appeals, Predatory publishers and journals.

**Unit-III Open Access Publishing**
Open access publications and initiatives, SHERPA/RoMEO online resource to check publisher copyright and self-archiving policies, Software tool to identify predatory publications developed by SPPU, Journal finder/journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

**Unit-IV Publication Misconduct**
Group discussions on -Subject specific ethical issues, FFP, authorship, Conflicts of interest, Complaints and appeals: examples and fraud from India and abroad, Using Software tools - Anti-plagiarism tools like Turnitin, Urkund and other open source software tools.

**Unit-V Databases and Research Metrics**
Databases - Indexing databases, Citation databases: Web of Science, Scopus etc., Research Metrics - Impact factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score, h-index, g index, i10 index, altmetrics, Citation of bibliography using Mendeley.

**Suggested Reading**:


1. RESEARCH & PUBLICATION ETHICS by Wakil kumar Yadav, JitendranathGorai, Ms Seema Shukla, Yogendra Kumar, Dr Dinesh Sriwash, Dr Dev Brat Mishra, Dev Kamlesh Paswan, NOTION PRESS, India, Singapore-Malesia, ISBN-13:9781685546717.
2. RESEARCH & PUBLICATION ETHICS, A COMPLETE GUIDE TO CONDUCTING & PUBLISHING RESEARCH ETHICALLY, by enago academy.
3. Research and Publication Ethics: A Textbook,March 2022,Edition: First edition, Publisher: Concept Publishing Company Pvt. Ltd., New Delhi, ISBN: 978-93-5439-084-5
4. Elsevier | Ethics in Research & Publication, ethics.elsevier.com.


**Course learning outcome (CLO):**

On completion of this course, the students will be able to:

1. Describe philosophy, ethics and scientific conduct.
2. Explain the publication ethics and publication misconduct.
3. Understand open access publication, databases and research metrics

# Protein Engineering
# (Elective)
# Code: PBT711

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**Course Objectives (CO)**

1. Introduce the structure and classification of proteins
2. Introduce the DNA sequence of proteins for factors which can affect the expression and properties of the protein.
3. To familiarize students with concepts of designing a new protein molecule

**Unit I Structure of Proteins**

Post translational Modifications of proteins, Primary Structure and its determination, Ramachandran Plot. Secondary, Tertiary and Quaternary Structure of Protein, Bonds that stabilize a Protein molecule, Protein folding pathways and energy status of protein molecule, Protein Degradation in the cell.

**Unit II Techniques Involved in Studying Protein Structure**

Methods of protein crystallization, Methods to study the quaternary structures of proteins: X-ray Crystallography, NMR Spectroscopy. MALDI-TOF, ESI-MS, Protein expression and purification, Types of chromatography – Affinity, Anion exchange, Cation exchange, Column, HPLC, GC, LC-MS etc.

**Unit III Structure Function Relationships in Proteins**

Helix-turn-Helix motif in DNA binding and homeodomain protein, Zinc fingers, Leucine zippers, Membrane proteins: General characteristics, Transmembrane segments, bacteriorhodopsin and Photosynthetic reaction center

**Unit IV Concepts of Designing a New Protein Molecule**

Chemical synthesis of peptides, Target molecules for Protein Engineering, the protein cycle and steps involved in Engineering a new Protein, De novo protein design.

**Unit VApplications of Protein Engineering**

Protein Engineering to enhance the solubility and assist folding of expressed proteins, Protein Engineering to assist purification of expressed proteins, Role in Vaccine Development, Engineering blood clotting factors: factor VIII. Engineering enzymes: tyrosyl-tRNA synthase, Engineeringtherapeutic hormones: insulin, Engineering humanized antibodies.

**Suggested Readings:**

1. Protein Engineering,Approaches to the Manipulation of Protein Folding, 1st Edition - March 26, 1990. Editor: Saran A. Narang eBook ISBN: 9781483161280

2. Protein Engineering: Tools and Applications, Huimin Zhao, Sang Yup Lee, Jens Nielsen, Gregory Stephanopoulos. First published:19 August 2021 Print ISBN:9783527344703 Online ISBN:9783527815128 DOI:10.1002/978352781512
3. Extraction and purification methods in downstream processing of plant-based recombinant proteins. Łojewska E, Kowalczyk T, Olejniczak S, Sakowicz T. Protein Expr Purif. 2016 Apr;120:110-7. doi: 10.1016/j.pep.2015.12.018. Epub 2015 Dec 29.
4. "Protein Engineering" by Moody P C E and Wilkinson A J.

**Course Learning Outcome (CLO):**

On completion of this course, students should be able to:

1. Analyze and compare the amino acid sequences and structures of proteins and relate this information to function.
2. Understand the function of individual amino acids and their influence on the solubility, structure, and function of proteins
3. Understand the purification of proteins on a milligram scale by biochemical methods and perform a protein crystallization experiment

# Biomaterials Engineering
# (Elective)
# Code:PBT712

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**Course Objectives (CO)**

1. To introduces properties, processing/fabrication and application of materials derived from or associated with bio-entities.
2. To familiarize students with biomaterials with broad applications beyond medical or clinical uses.
3. To make students understand the biological systems unique machinery and function of Biomaterials

**Unit I Introduction**

Definition of biomaterials, requirements & classification of biomaterials, Comparison of properties of some common biomaterials. Effects of physiological fluid on the properties of biomaterials. Biological responses (extra and intra-vascular system). Surface properties of materials, physical properties of materials, mechanical properties.

**Unit II Metallic implant materials**

Stainless steel, Co-based alloys, Ti and Ti-based alloys. Importance of stress-corrosion cracking. Host tissue reaction with bio metal, corrosion behavior and the importance of passive films for tissue adhesion. Hard tissue replacement implant: Orthopedic implants, Dental implants. Soft tissue replacement implants: Percutaneous and skin implants, Vascular implants, Heart valve implants-Tailor made composite in medium.

**Unit III Polymeric implant materials**

Polyolefin's, polyamides, acrylic polymers, fluorocarbon polymers, silicon rubbers, acetyls. (Classification according to thermo sets, thermoplastics and elastomers).Viscoelastic behavior: creep-recovery, stress-relaxation, strain rate sensitivity. Importance of molecular structure, hydrophilic and hydrophobic surface properties, migration of additives (processing aids), aging and environmental stress cracking. Physiochemical characteristics of biopolymers. Biodegradable polymers for medical purposes, Biopolymers in controlled release systems. Synthetic polymeric membranes and their biological applications.

**Unit IV Ceramic implant materials**

Definition of bio ceramics. Common types of bioceramics: Aluminum oxides, Glass ceramics, Carbons. Bio resorbable and bioactive ceramics. Importance of wear resistance and low fracture toughness. Host tissue reactions: importance of interfacial tissue reaction (e.g. ceramic/bone tissue reaction).Composite implant materials: Mechanics of improvement of properties by

incorporating different elements. Composite theory of fiber reinforcement (short and long fibers, fibers pull out). Polymers filled with osteogenic fillers (e.g. hydroxyapatite). Host tissue reactions.

**Unit VBiocompatibility & Toxicological screening of biomaterials**

Definition of biocompatibility, blood compatibility and tissue compatibility. Toxicity tests: acute and chronic toxicity studies (in situimplantation, tissue culture, haemolysis, thrombogenic potential test, systemic toxicity, intracutaneous irritation test), sensitization, carcinogenicity, mutagenicity and special tests.

**Suggested Readings:**

1. Biomaterials Science: An Introduction to Materials in Medicine, By Buddy D. Ratner, et. al. Academic Press, San Diego, 1996.
2. Sujata V. Bhat, Biomaterials, Narosa Publishing House, 2002.
3. J B Park, Biomaterials – Science and Engineering, Plenum Press, 1984.

**Course Learning Outcome (CLO):**

On completion of this course, students should be able to:

1. Explain the properties of various biomaterials
2. Select appropriate methods that can help address specific materials, properties and processing
3. Apply the chemistry and engineering knowledge gained to solve challenges in biomaterials

# Biofuels & Bioenergy
# (Elective)
# Code: PBT713

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**Course Objectives (CO)**

1. To introduce the student to the different areas in which biotechnology is developed and to environmental application methods in terms of biofuels & bioenergy
2. Emphasize knowledge of the different types of environmental biotechnologicalprocesses that exist in the field of Global Energy Scenario.
3. To introduce the iimpact of energy systems on environment

**Unit I Energy Resources**

Coal, Oil, Natural Gas, Nuclear Power and Hydroelectricity, Solar, geothermal, tidal and wave energy. Depletion of energy sources and impact, exponential rise in energy consumption on economies of countries and on international relations. Need for use of new and renewable energy sources. Status of Nuclear and Renewable Energy: Present Status and future promise, Hydrogen and fuel cell, Waste as a source of energy: Industrial, domestic and solid waste as a source of energy.

**Unit II Bio fuels**

What are biofuels? Need, Advantages and limitations of biofuels. Debates regarding the production and use of biofuel. first, second , third and fourth generation biofuels. Production and impacts of bioethanol, biohydrogen, biogas , bioelectricity and biodiesel.

**Unit I1I Global Energy Scenario**

Role of energy in economic development and social transformation: Energy & GDP, GNP and its dynamics. Exponential increase in energy consumption and Projected future demands - International Energy Policies of G-8 Countries, G-20 Countries, OPEC Countries, EUCountries. International Energy Treaties (Rio, Montreal, Kyoto), INDO-US Nuclear Deal. Future Energy Options: Sustainable Development, Energy Crisis: Transition from carbon rich and nuclear to carbon free technologies.

**Unit IV Indian Energy Scenario**

Fossil fuels, Renewable sources including Bio-fuels in India, their utilization pattern in the past, present and future projections of consumption pattern, Sector wise energy consumption, Impact of Energy on Economy, Development and Environment, Need for use of new and renewable energy sources. Status of Nuclear Energy. Energy, Energy Conservation Act-2001 & its features, Electricity Act-2003 & its features. Framework of Central Electricity Authority (CEA), Central

&States Electricity Regulatory Commissions (CERC & ERCs) , Jawaharlal Nehru National Solar Mission.

**UnitV Impact of Energy Systems on Environment:** Environmental degradation due to energy production and utilization, Primary and Secondary pollution such as $SO_2$, $NO_2$, SPM in air, thermal and water pollution, depletion of ozone layer, global warming, Green House Gases Emission, biological damage due to environmental degradation. Sociological and Economical problems due to Thermal and other energy projects. Physiological, ecological and environemtal and health problems due to energy plants. Effect of Hydro electric power stations on ecology and environment. Environmental pollution limits guidelines for thermal power plant- Various pollution control equipments , Limitations and advantages of pollution control systems. Nuclear power plants and environmental pollution, pollution control measures. Pollution due to vehicles and Control emission from Vehicles

**Suggested Readings:**


1. Energy for a sustainable world: Jose Goldenberg, Thomas Johansson, A.K.N.Reddy, Robert Williams (Wiley Eastern).
2. Energy policy for :B.V.Desai (Weiley Eastern).
3. TEDDY Year Book Published by Tata Energy Research Institute (TERI).
4. World Energy Resources : Charles E. Brown, Springer2002.
5. Environmental Impact Analysis Handbook -J.G.Rau, D.C.Wood (McGraw Hill).
6. Energy & Environment – J.M. Fowler, (McGrawHill)
7. Web site of Ministry of New and renewable energy.


**Course Learning Outcomes (CLO):**

On completion of this course, students should be able to:

1. Understand and assimilate the specific concepts and terminology of environmental biotechnology.
2. Find and manage information from various Energy Resources and Bio fuels
3. Describe the scientific bases that are applied by environmental biotechnology.

# Enzyme Engineering
# (Elective)
# Code: PBT714

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**Course Objectives (CO)**

1. This course is designed to equip the students with Advance knowledge of Enzyme Kinetics, Optimization and modeling of Enzyme Systems.
2. Students will be able to design enzymatic process, after the completion of the course.
3. Enzyme engineering course focuses from isolation to modification of enzyme by the applications of biotechnology.

**UNIT I Properties of Enzymes**

Introduction, nomenclature and scope of Enzymes. Mechanism of enzyme action, concept of ES complex, Active sites. Specificity of enzymes, Enzyme UNITs and turn over number.

**UNIT II Enzyme Kinetics**

Order of reactions, kinetics of enzyme reactions- single, bi substrate reactions. Michaelis-Menten Equation. Estimation of Km and Vmax and their physiological significance. Allosteric enzymes, their role in controlling metabolic pathways.

**UNIT III Enzyme Immobilization**

Physical and chemical techniques for enzyme immobilization- adsorption, matrix- entrapment, encapsulation, cross linking and covalent bonding etc. Advantages and disadvantages of enzymes immobilization. Temperature dependence of enzymatic rate constant, thermal deactivation. pH dependence of enzymes- ionization of acids and bases.

**UNIT IV Isolation, Purification and Characterization of Enzymes**

Isolation, purification and characterization of enzymes. From natural sources. Preparation of purification chart once the purification is done. Different methods of enzyme characterization- SDS-PAGE, 2-D etc. Case studies and discussion on the research papers based on enzyme isolation.

**UNIT V Industrial Applications of Enzymes**

White Biotechnology: Examples of enzyme applications in industrial process, production of drugs and fine chemicals. Enzyme based Biosensors. Enzymes in organic catalysis. Enzyme Engineering, site directed mutagenesis and other methods of enzyme production. In vitro methods of enzyme modifications by protein expression.

**Suggested Readings:**


1. Voet and Voet (1990) Biocehmistry John Wiley & Sons, New York
2. Palmer T and Bonner TL (2007) Enzymes: Biochemistry, Biotechnology and Clinical Biochemistry

3. Jeremy Mark Berg, John l., Tymoczko and Stryer L., (2002) Biocehmistry WH Freeman New York
4. Harrison R. G., Todd P., Rudge S. R. (2003) Bioseparation Science and Engineering, Oxford Press, Oxford.

**Course Learning Outcomes (CLO):**

On completion of this course, students should be able to:

1. Analyze the data obtained for enzymes, appreciate the utility of enzymes in various industries**.**
2. Design new enzymes for future.
3. Optimize the conditions for improving the enzyme production and making them tolerant to harsh conditions.
4. Interpret the laws of enzyme kinetics.

# Pharmaceutical Biotechnology
# (Elective)
# Code: PBT715

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**Course Objectives (CO)**

1. The syllabus will help the students to be familiar with various biotech industries dealing with processing and production of products, obtained from natural and synthetic drugs.
2. Students will understand the various techniques used in modern pharmaceutical biotechnology.
3. This course tries to create a synergy between industrial pharma and industrial biotechnology.
4. Syllabus will help in focusing on the pharmaceutical, medical and therapeutic properties of numerous biopharmaceutical products

**UNIT I Introduction to Pharmaceutical industries**

Industrial aspects: Pharmaceutical biotechnology information- biopharmaceutical drugs & biotechnology products made by biotech companies, Stability studies of biotechnology derived products, Effects of various environmental /processing on stability of the formulation and techniques for stabilization of product against the same regulatory requirement related to stability testing.

**UNIT II Broad spectrum of Pharmaceutical products**

Herbal and naturally derived Products: - Formulation development aspects, Delivery aspects for herbal and naturally derived medicinal products (Herbal extracts, crud extracts, incorporation of product performance enhancers, etc.). Synthetic and Semisynthetic medicines, Formulation development aspects, Delivery aspects for Synthetic and Semisynthetic medicines, Regulatory considerations with consideration of global regulatory guidelines.

**UNIT III Quality checks and control in Pharma industries**

General Considerations, Spectroscopy and Assay development, dissociation, partitioning and Solubility of Pharmaceutical Solids, pKa, salts, solvents, Ko/w, drug design, phase solubility analysis, solubilization, release, dissolution and permeation, chiral drug substances, characterization scheme.

**UNIT IV Pharmaceutical drugs with focus on enhancing shelf life**

Dosage form consideration in pre-formulation, solid dosage form, solution formulations, emulsion, suspension, freeze dried products, topical, pulmonary, evaluations and its regulatory considerations, stability tastings, order of reaction, antioxidants, chelating agents, impurity, GMP related to bulk drugs and APIs.

**UNIT V Pharmaceutical drugs for treating the diseases**

Industrial application of biotech products: industrial enzymes (examples), immobilization of enzymes, their applications in industry, Immobilized Enzyme engineering, Kinetics of immobilized enzymes, novel methods for enzyme and vaccine production.

**Suggested Readings:**


1. Pharmaceutical Biotechnology: Fundamentals and Applications, edited by Daan J.A. Crommelin, Robert D. Sindelar, Bernd Meibohm, fundamental and applications, 4th edition, 2013 Springer.
2. Biotechnology: Expanding Horizons B.D. Singh, Kalayani Publishers, Biotechnology 2010
3. Comprehensive Biotechnology (Vol. 1-4): M.Y. Young (Eds.), Pergamon Press,Oxford, 2007.
4. Introduction to the Pharmaceutical Sciences, By Nita K. Pandit, Lippincott Williams & Wilkins, 2007.


**Course Learning Outcomes (CLO):**

On completion of this course, students should be able to:

1. Analyze scientific principles underlining modern biotechnology subject aimed specifically at pharmacy and medicines.
2. Design research strategy with step -by -step instructions to address a research problem.
3. Provide examples of current applications of biotechnology and advances in the different areas like medical, microbial, environmental, bioremediation, agricultural, plant, animal, and virology.
4. Modify and improve their learning and understanding of the subject

# Artificial Intelligence in Biological Research
# (Elective)
# Code: PBT715

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**Course Objectives (CO):**

1. To understand the fundamentals of Artificial Intelligence (AI), machine learning, and deep learning.
2. To explore the application of AI tools in genomics, proteomics, systems biology, and biomedical research.
3. To develop problem-solving and computational skills using AI techniques.
4. To critically analyze biological data using AI frameworks and tools.
5. To apply AI models for hypothesis generation, experimental design, and biological predictions.

**UNIT I: Introduction to AI and Biological Data**

History and definition of AI, ML, DL, Types of biological data: genomic, transcriptomic, proteomic, metabolomic, Challenges in biological data: heterogeneity, noise, dimensionality, Overview of data acquisition and preprocessing, AI in hypothesis generation and biomarker discovery

**UNIT II: Machine Learning Fundamentals for Biology**

Supervised vs Unsupervised Learning, Common algorithms: Decision Trees, SVM, k-NN, Random Forest, Feature selection and dimensionality reduction (PCA, t-SNE), Case studies: Classification of gene expression data, cancer subtype prediction, Tools: Scikit-learn, Orange, WEKA

**UNIT III: Deep Learning Applications in Biology**

Neural networks: basic concepts and architecture, Convolutional Neural Networks (CNNs) for biological imaging, Recurrent Neural Networks (RNNs) for sequence data, Autoencoders for noise reduction and feature learning, Applications in diagnostics, drug discovery, and genomics

**UNIT IV: AI in Omics and Systems Biology**

AI in genomics: variant calling, genome annotation, AI in proteomics: protein structure prediction (AlphaFold), Metabolomics and system-level modelling, AI in personalized medicine and clinical trials, Ethical considerations and data privacy in biological AI

**UNIT V: Practical Applications and Case Studies**

Project-based learning: Designing an AI model using real biological data. Workflow: data collection → preprocessing → modeling → evaluation. Case studies: CRISPR gene editing prediction, Protein–ligand interaction modelling, AI in epidemiology and pandemic prediction, Tools: TensorFlow, Keras, BioPython, BioConductor (R)

Suggested Readings:


1. Eraslan, G., et al. (2019). *Deep learning: new computational modelling techniques for genomics*. Nature Reviews Genetics.
2. Libbrecht, M. W., & Noble, W. S. (2015). *Machine learning applications in genetics and genomics*. Nature Reviews Genetics.
3. Chicco, D., & Jurman, G. (2020). *Machine learning can predict survival of patients with heart failure from serum creatinine and ejection fraction alone*. BMC Medical Informatics.
4. Alpaydin, E. (2020). *Introduction to Machine Learning*, 4th Ed. MIT Press.
5. Le, N. Q. K. et al. (2021). *Artificial Intelligence in Bioinformatics*. Elsevier.
6. Goodfellow, I., Bengio, Y., & Courville, A. (2016). *Deep Learning*. MIT Press.
7. Zou, J. et al. (2019). *A primer on deep learning in genomics*. Nature Genetics.


**Course Learning Outcomes (CLOs):** By the end of this course, the scholars will be able to:

1. Explain the principles and types of AI and their relevance in biological contexts.
2. Demonstrate the use of supervised and unsupervised machine learning in biological data analysis.
3. Apply AI techniques in genomics, drug discovery, and image-based biological research.
4. Analyze complex biological datasets using AI tools such as Python, R, and deep learning frameworks.
5. Design and implement basic AI models for solving real-world biological research problems.

# Modern Pharmaceutical Analytical Techniques
# (Open Elective)
# Code: PHS 709

| L | T | P | C |
|---|---|---|---|
| 3 | 0 | 0 | 3 |

**Course Objectives (CO)**

1. To promote research in advanced areas of science and technology.
2. To provide advanced instrument knowledge to research scholars.
3. To enhance the skill of scholar for use/operation/applications of sophisticated instruments.

**Course Contents**

**Unit I Nuclear Magnetic Resonance spectroscopy**

Principles of H-NMR and C-NMR, chemical shift, factors affecting chemical shift, coupling constant, Spin–spin coupling, instrumentation and applications.

**Unit II Mass Spectrometry**

Principles, Fragmentation, Ionization techniques electron impact, chemical ionization, and Quadrupole, instrumentation, applications.

**Unit III UV Spectroscopy**.

Electronic transitions, principles, chromophores, auxochromes, spectral shifts, solvent effect on absorption spectra, Beer and Lambert's law, deviations, instrumentation and pharmaceutical applications.

**Unit IV IR spectroscopy including Theory,**

Modes of Molecular vibrations, Sample handling, Instrumentation of IR Spectrometer, Factors affecting vibrational frequencies, Applications of IR spectroscopy and Data Interpretation.

**Unit V Chromatography**

Principle of Chromatography, apparatus, instrumentation and pharmaceutical applications of absorption, partition chromatography, Thin Layer chromatography, GLC and HPLC.

**Suggested Readings:**

1. Instrumental Methods of Analysis: Willard, N., CBS Publishers, New Delhi.
2. Douglas A. Skoog, Principles of Instrumental Analysis, 6th Edition, 2007.
3. Indian Pharmacopoeia 1996, Volume I and Volume II, Controller of Publications, Delhi.

**Course Learning Outcome (CLO)**

At the end of the course, the student should be able to:

1. Discuss the advanced areas of science and technology.
2. Describe advanced instrument utility for the research scholars.
3. Aware of Use/operate/apply sophisticated instruments in the research.

# Ayurveda Perspectives of Research Methodology
# (Open Elective)
# Code: PAY 701

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**Course Objectives (CO)**

1. To promote research ideas in various fields of Ayurveda Science.
2. To develop integrated research approaches for advanced studies in the field of Ayurvedic science.
3. To create awareness of integrated research in fundamental, drug and clinical studies.

**Unit I: Ayurvedic Research Methodology**

- Empirical Researches according to Acharya Charak
- Evidence based research as found in later Samhita
- Shastra Lakshan (ideal texts), Tantra Yukti
- Research based literature terminology as found in Samhita
- AYUSH Research Portal, UGC Care list

**Unit II: Literary and Fundamental Research in Ayurveda**

- Ancient manuscripts/ rare books, collection and compilation related to drugs and diseases
- Popular commentaries and translation on Brihatryi and need of further addition
- Traditional Knowledge and Digital Library (TKDL)
- Contemporary literature and publications related to Ayurveda
- Lexicographic work

**Unit III: Drug Research in Ayurveda**

- Aushadhi lakshan (ideal drug)
- Collection of raw drugs
- Good Manufacturing Practices (related to ASU drugs)
- Pharmacognostic and pharmacological aspects as found in Ayurveda
- Reverse pharmacology
- Recent publications and finding in ayurvedic drug research
- Medico-Ethno Botanical Survey, parts of major Forest divisions
- The Ayurvedic Formulary of India, The Ayurvedic Pharmacopeia of India, NMPB
- Advance techniques and instruments used in drug research

**Unit IV Clinical Research in Ayurveda**

- Principles and applied aspects of diagnostic & therapeutic techniques in ayurveda
- Method of patient examination (Rogi Pariksha)
- Concept of Prakriti- Vikriti
- Clinical research designing and Standard questionnaires as per ayurvedic perspectives
- Good Clinical Practices

- Recent publications related to clinical research in ayurveda

**Suggested Readings;**

1. P. V. Sharma, “Charak Samhita,” Chaukhambha Orientalia, Varanasi, 1983.
2. Anonymous, Research Publications in Ayurvedic Sciences, Catalogue of Research information on Ayurveda and Related Sciences, Central Council of Research in Ayurveda Sciences, Ministry of Ayush, GoI, New Delhi 2015; http://ccras.nic.in
3. Ranjit Kumar (2011). Research Methodology, a Step-by-Step Guide for Beginners (3rd ed.). New Delhi: SAGE Publishers Ltd.
4. Kothari, C.R. (2019) Research Methodology: Methods and Techniques. 4th Edition, New Age International Publishers, New Delhi.

**Course Learning Outcome (CLO)**

At the end of the course, the scholar should be able to:

1. Discuss the advanced areas of research in Ayurveda by knowing the basic principles of ayurveda.
2. Describe the integrated research areas by utilizing the advanced instrument for the drugs research.
4. Aware of applied aspects of diagnostic instruments in the Ayurvedic clinical research.

## Microbial Metabolism

## (Open Elective)
## Code:PMM 706

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**Course Objectives (CO)**

1. To study the micro-organisms types based on nutrition and transport.
2. To study the growth of microorganisms and effect of environmental factor on growth.
3. **To study about phototrophic metabolism in microorganisms.**
4. To promote research in advanced areas of Microbial gap.

**UNIT-I Microbial growth and growth kinetics:**
Bacterial growth curve, generation time, measurement of microbial growth, growth kinetics, synchronous culture, continuous and batch culture, chemo static and turbidostatic, environmental factors affecting growth, nutritional diversity in bacteria. Solute transport**:** Active and passive transport ,Primary and secondary transport, Transport kinetics, ABC transporter, PEP-PTS system, catabolite repression, inducer expulsion.

**UNIT-II Diversity and regulation of glucose metabolism in microbes:**
Embden-Meyerhof-Parnas pathway - Variations of EMP pathway in different groups of bacteria; Overall balance sheet; Regulation; Modes of NAD regeneration; alcoholic and lactic acid fermentation, Pentose phosphate pathway – HMP pathway and its link with glycolysis, Fermentative mode of glucose oxidation - Entner-Doudoroff pathway; variations of ED pathway in different groups of microbes and its implications, Fate of pyruvate, Citric acid pathway – Stoichiometry and energy gain; Regulation; Alternate forms of TCA; ReductiveTCA;BranchedTCA;Glyoxylatecycle.

**UNIT-III Nitrogen metabolism:**
Nitrogen assimilation, GS-GOGAT pathway and its regulation, Utilization of other modes of nitrogen, nitrate and nitrite utilization, amino acid biosynthetic pathways and their regulation, amino acid utilization – reduction amination and deamination; decarboxylation; Stickland reaction; amino acid oxidases, polyamine biosynthesis and utilization.

**UNIT-IV Lipid metabolism:**
Biochemistry of lipids, lipid distribution in different groups of microbes, fatty acid biosynthesis, synthesis of different types of lipids – neutral lipids; phospholipids and glycolipids, biosynthesis of archaeal lipids, synthesis of storage lipids, lipid utilization, beta-oxidation pathway – regulation and energy calculation, Lipid accumulation pathway, biochemical and molecular distinction between oleaginous and non-oleaginous microbes.

**UNIT-V Programming metabolism in relation to overproduction of selected metabolites:**
Introduction to primary and secondary metabolism, classification of secondary metabolites, introduction to metabolic engineering – strain development and pathway engineering, Case

studies on primary metabolites viz. citric acid, succinic acid, lactic acid, ethanol fermentation, amino acid pathways (glutamate, lysine, shikimic acid), Case studies on secondary metabolites viz. polyhydroxyalkanoates, polyketides and antibiotics

**Recommended Books**


1. "Physiology and Biochemistry of Prokaryotes" by David White, published byOxford University Press, 4th edition, 2011.
2. "Microbial Biochemistry" by G. N. Cohen published by Springer Netherlands, 3rd edition, 2014.
3. "Microbial Physiology" by Albert G. Moat, John W. Foster, Michael P. Spector, published by John Wiley & Sons, 4th edition, 2002.
4. "Biochemistry" by Geoffrey Zubay, published by William C Brown, 4th edition, 2002
5. "The Metabolic Pathway Engineering Hand book" by Christina Smolke, published by CRC Press, 2009.


**Course learning outcome**

After completing the course, the students will able to:

1. Classify the micro-organisms types based on nutrition and transport.
2. Study the growth of microorganisms and effect of environmental factor on growth.
3. Study about phototrophic metabolism in microorganisms.
4. Study the mechanism and types of microbes.

## Omics Technology
## (Open Elective)
## Code: PBT722

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**Course Objectives (CO)**

1. To introduce basics of Omics terminologies and scope.
2. To introduce genomics, transcriptomics and metabolomics
3. To introduce mechanisms underlying the complex architecture of many phenotypic traits of agricultural relevance.
4. To introduce biochemical and molecular markers

**Unit I Omics terminologies and scope**

Omics and its relevance in agriculture; Definitions, terminologies and scope in crop improvement.

**Unit II Biochemical and Molecular markers**

Morphological, biochemical and DNA-based markers (RFLP,RAPD, AFLP, SSR, SNPs, ESTs etc.), mapping populations (F2s, back crosses, RILs, NILs and DH). Molecular mapping and tagging of agronomically important traits.Statistical tools in marker analysis, Robotics; Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants, Gene pyramiding.

**Unit III Marker assisted selection**

molecular breeding; Genomics and genoinformatics for crop improvement; Integrating functional genomics information on agronomically/economically important traits in plant breeding; Marker-assisted backcross breeding for rapid introgression, Generation of EDVs.

**Unit IV rDNA Technology**

Recombinant DNA technology, transgenes, method of transformation, selectable markers and clean transformation techniques, vector-mediated gene transfer, physical methods of gene transfer.

**Unit V Transgenic Production**

Production of transgenic plants in various field crops: cotton, wheat, maize, rice, soybean, oilseeds, sugarcane etc. Commercial releases, molecular farming.

**Suggested Readings:**


1. Genomes by T.A. Brown, John Wiley & Sons Ltd, New York
2. Genome analysis (Volume I, II, III and IV) a Laboratory Manual by Bruce Birren,Eric D. Green, Sue Klapholz, Richard M. Myers and Jane Roskams, Cold SpringHarbor Laboratory Press.
3. Discovery Genomics, Proteomics and Bioinformatics, Campbell AM &Heyer L, 2004


**Course Learning Outcomes (CLO):**

On completion of this course, the students will be able to:

1. To describe the combination of genomics, transcriptomics and metabolomics
2. Understanding of the mechanisms underlying the complex architecture of many phenotypic traits of agricultural relevance.
3. To understand the basic knowledge of Omics terminologies and scope.
4. To understand the uses of biochemical and molecular markers

# Human Metabolic Disorders
# (Open Elective)
# Code: PMB 722

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**Course Objectives (CO)**

1. To demonstrate advanced understanding of key aspects of biochemistry and molecular biology at the individual organ and system level and the integration between body systems.
2. To demonstrate understanding of how alterations to normal body biochemistry can contribute to disease.
3. To demonstrate understanding of key biochemical, molecular biology, genetic and analytical techniques, including state of the art technologies used in understanding the biochemistry of human disease.

**Unit I Introduction**

Basic Enzymology, Overview of Carbohydrate Metabolism/Glycogen Storage Disorders, Disorders of Fructose Metabolism, Galactose Metabolism, Diabetes and Hypoglycemia.

**Unit II Amino Acid Metabolism**

Overview of Amino Acid Metabolism, Disorders of Amino Acid Metabolism, disorders of Urea cycle and inborn errors.

**Unit III Nucleic Acid Metabolism**

Overview of Nucleic Acid Metabolism, Disorders of Purine Metabolism, Disorders of Pyrimidine Metabolism and Porphyrias.

**Unit IV Energy Metabolism**

Overview of Energy Metabolism / Pyruvate Metabolism and the TCA Cycle, Disorders of Beta Oxidation and Electron Transport Chain.

**Unit V Lipid Metabolism**

Overview of Lipid and Lipoprotein Metabolism, Dyslipidemias, Disorders of Cholesterol and Bile Acid Synthesis and Storage, Glycolipids and Complex Carbohydrates, Lysosomal Storage Disorders, Organelle Function Disorder.

**Suggested Readings:**


1. Lehninger Principles of Biochemistry, Eighth Edition| ©2021.
2. Biochemistry, 4th Edition, Donald Voet, Judith G. Voet


**Course Learning Outcome (CLO)**

At the end of the course, the student should be able to:

1. Explain advanced understanding of key aspects of biochemistry and molecular biology at the individual organ and system level and the integration between body systems.
2. Explain how alterations to normal body biochemistry can contribute to disease.
3. Discuss key biochemical, molecular biology, genetic and analytical techniques, including state of the art technologies used in understanding the biochemistry of Human disease.