

**PhD program in Biotechnology**  
**Under**  
**Regional Centre for Biotechnology, Faridabad**  
**and**  
**Center of Innovative and Applied Bioprocessing,**  
**Mohali**

**Center of Innovative and Applied Bioprocessing**  
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# PhD Course Work

Rules and Regulation of PhD program are as per Regional Centre for Biotechnology (RCB) Regulation, 2017 (notified on September 15th, 2017 in The Gazette of India)

## **OBJECTIVES OF PhD PROGRAMME**

The programme envisages advanced training and translational research on biotechnology and synthetic biology, food nutrition and engineering, chemical bioproducts and chemical engineering with particular emphasis on utilization of agro-residues for value added products. The specific objectives of the programme are to develop researchers with the following competencies:

1. To prepare skilled and successful professionals for research institutions, industry, and entrepreneurial pursuits.
2. To prepare specialists in the field of bioprocess for value added products from biomass
3. To contribute towards skill and innovation as well as societal uplift.

## **GOALS OF PhD PROGRAMME**

PhD programme in Biological Sciences, Chemical Sciences, Food Science & Engineering and Chemical Engineering has been designed to develop highly skilled and specialized researchers with the goal of sustainable technological development in a contemporary, global, economical, environmental and societal context.

**All the academic rules will be as per the relevant RCB ordinances, statutes and regulations.**

#### NATURE OF DOCTOR OF PHILOSOPHY PROGRAMME

The Doctor of Philosophy Programme at NABI shall consist of two components, namely:-

- (a) PhD course work and
- (b) Research work leading to the submission of a doctoral thesis.

#### **ACADEMIC CALENDER**

<b>ACTIVITY</b>	<b>DATES</b>
<b>MONSOON SEMESTER (JULY TO DECEMBER)</b>	
Registration	Last week of July
Commencement of Semester	1 <sup>st</sup> week of August
Reporting to the Advisor(s)	2 <sup>nd</sup> week of August
Mid-Term Examination	1 <sup>st</sup> week of October
End-Semester Examination	1 <sup>st</sup> week of December
Synopsis/ Research Progress (Report and Presentation)	3 <sup>rd</sup> week of December
Submission of marks by Examiners	End of December
<b>AUTUMN SEMESTER (JANUARY TO JUNE)</b>	
Registration	1 <sup>st</sup> week of January

## PhD COURSES

<b>Semester – I</b>		
<b>Compulsory Course</b>		
<b>Course Code</b>	<b>Subject</b>	<b>Credit (4)</b>
CIA-401	Research Methodology	2
CIA-402	Analytical Instrumentation	2
<b>Elective Course</b>		
<b>Course Code</b>	<b>Subject</b>	<b>Credit (4)</b>
CIA-301	Advances in Biosynthetic Technology	2
CIA-302	Biological Macromolecules and Enzymology	2
CIA-303	Advances in Organic and Material Chemistry	2
CIA-304	Natural Product Chemistry	2
CIA-305	Food Process Technology	2
CIA-306	Advances in Food Engineering	2
CIA-307	Process Technology	2
CIA-308	Chemical Process Design	2

### **Total credits: 08**

Students entering into the PhD Programme at CIAB shall have to complete mandatory courses, CIA-401 Research Methodology and CIA-402 Analytical Instrumentation in the first semester and Elective courses in the second semester. Total 8 credits have to be completed in 01 to 02 semesters for PhD candidates.

Synopsis/research progress (Report and Presentation) are mandatory activities for the PhD candidates and will be awarded as satisfactory or unsatisfactory grades evaluated by Student Advisory Committee (SAC) on the basis of students' performance.

**COMPULSORY COURSE**  
**CIA-401**  
**RESEARCH METHODOLOGY**  
**2 credit course**

*This course is designed to gain knowledge of the systematic research approach and planning of work based on comprehensive literature survey. The topics covered include the introduction to research methodology, literature survey and work plan, data mining and interpretations, writing and presentation skills, and research tools and regulations.*

**COURSE CONTENT**

**Introduction to research methodology**

Definitions and characteristics of research, types of research, main components of any research work, problem identification, criteria for prioritizing problems for research.

**Literature survey and work plan**

Uses of literature review, source of information, organization of information on index cards, advanced search tools, analyzing the problem, formulating the problem statement, formulation of the research objectives, major components and outline of the different phases in a research process.

**Data mining and interpretations**

Methods of data collection, plan for data processing and analysis, ethical considerations, summary of the major components of a research proposal.

**Writing and presentation skills**

Introduction to presentation tool, writing research reports and manuscripts, features & functions, making presentations, customizing presentation.

**Research tools and regulations**

Bioinformatics, biostatistics, biosafety, criteria for good scientific practice, research reports and manuscripts preparation. Intellectual property (IP) rights and management, ethics of research and plagiarism

**SUGGESTED READING**

1. Creswell, J. W. Research design: Qualitative, quantitative and mixed methods approaches, 4<sup>th</sup> Ed. Thousand Oaks publishing.
2. C. R. Kothari. Research Methodology: Methods and Techniques, II Ed., New Age International.
3. Montgomery C. Douglas. Design and Analysis of Experiments, 5<sup>th</sup> Ed., Wiley India.
4. Krishnswamy, K.N., Shivkumar, Appa Iyer and Mathiranjana M. Management Research Methodology; Integration of Principles, Methods and Techniques, I Ed., Pearson Education.

**CIA-402**  
**ANALYTICAL INSTRUMENTATION**  
**2 credit course**

*This course aims to provide basic knowledge and principle on a wide range of techniques required to characterize the materials produced via chemical and biological routes. The topics covered include the typical spectroscopic and microscopic techniques, elemental, structural and surface analysis methods, thermal analysis tools and techniques for (food) biotechnology.*

**COURSE CONTENT**

**Spectroscopic techniques**

Ultraviolet-visible (UV-vis), infrared (IR), nuclear magnetic resonance (NMR), mass spectrometry (MS) and electron paramagnetic resonance (EPR).

**Separation and microscopic techniques**

High pressure liquid chromatography (HPLC), gas chromatography (GC), atomic force microscopy (AFM), scanning electron microscopy (SEM) and transmission electron microscopy (TEM)

**Elemental, structural and surface analysis**

Inductively coupled plasma atomic emission spectroscopy (ICP-AES), X-ray photoelectron spectroscopy (XPS), X-ray diffraction (XRD) and chemisorption and physisorption techniques.

**Thermal analysis**

Thermogravimetric analysis (TGA) and Differential scanning calorimetry (DSC).

**Techniques in food technology**

Spray drying, fermentation, membrane filtration, dynamic light scattering, polarimeter, rancimat, rheometer, Kjeldahl for protein analysis.

**Techniques in molecular biology**

Polymerase chain reaction (PCR): basic principles, types, and advances, DNA and protein electrophoresis, DNA sequencing techniques, protein purification techniques.

**SUGGESTED READING**

1. Bryan M. Ham and Aihui MaHam. Analytical Chemistry: A Chemist and Laboratory Technician's Toolkit, Wiley publisher, 2016.
2. G. R. Chatwal and S. K. Anand. Spectroscopy, Himalaya publishing group, 2009.
3. Sandy B. Primrose and Richard Twyman. Principles of Gene Manipulation and Genomics, 7<sup>th</sup> Ed., Wiley-Blackwell.
4. Jack Cazes. Analytical instrumentation handbook, 3<sup>rd</sup> Ed., Taylor and Francis.

## ELECTIVE COURSES FOR ALL PH.D. STUDENTS

CIA-301

### ADVANCES IN BIOSYNTHETIC TECHNOLOGY

2 credit course

*This course offers the insight into advances of molecular biology and synthetic biology. The topics covered include fundamentals about genes, gene expression, gene mining, metagenomics, molecular cloning, and protein synthesis as well as advances in protein engineering, directed evolution, metabolic engineering and biosystems engineering.*

### COURSE CONTENT

#### **Fundamentals of molecular biology**

Fundamentals of genome, gene structure and organization, gene expression, the central dogma of molecular biology, proteins, protein synthesis, regulatory elements of gene expression, splicing and processing of RNA molecules.

#### **Molecular cloning**

DNA modification, PCR, separation and purification of DNA, DNA sequencing, DNA vectors for gene expression, designing of different vectors, selectable marker genes, reporter genes, nonselectable marker genes, and marker-free gene expression.

#### **Biosynthetic technology**

Gene synthesis, heterologous protein expression, protein engineering, directed evolution to genes, gene mining, metagenomics, metabolic engineering and synthetic metabolism, computational protein modelling, cell free protein synthesis, biosystems engineering and biomolecule production.

### SUGGESTED READING

1. Michael R Green and Joseph Sambrook. Molecular cloning a laboratory Manual. 4<sup>th</sup> Ed., Cold Spring Harbor.
2. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts and Peter Walter. Molecular Biology of the Cell, 7<sup>th</sup> Ed., Garland Science.
3. Paul S Freemont and Richard I Kitney. Synthetic Biology a Primer, Revised Ed., World Scientific publisher.

**CIA-302**  
**BIOLOGICAL MACROMOLECULES AND ENZYMOLOGY**  
**2 credit course**

*This course offers the insight into advances of biological macromolecules and enzymology aspects. This course covers basic and advance knowledge about the biological macromolecules such as protein, lipids, nucleic acid, and carbohydrates. The course also illustrates the basic concepts of enzyme kinetics and advance applications of enzymes in bioprocessing research.*

**COURSE CONTENT**

**Biological macromolecules**

Amino Acids, amino acid side chains, polypeptides, primary, secondary, tertiary, and quaternary structure of proteins, lipids, carbohydrates, nucleic acid, transcription and translation.

**Structure and function of macromolecules**

General structure, properties and functions of proteins, lipids, carbohydrates and nucleic acid

**Enzyme kinetics**

Enzymes, types of enzyme catalysts, enzyme stability (effect of temperature, pH and substrate concentration), enzyme regulation (product inhibition, feedback control, enzyme induction and repression and covalent modification), enzyme kinetics, Michaelis-Menton (forms and derivations of MM equation, significance of  $V_{max}$  and  $K_m$ ) and enzyme variants, Enzyme inhibition, types of inhibitors-competitive, non-competitive and uncompetitive and their mode of action.

**Enzymes and bioprocessing**

Enzyme engineering, applications of enzymes in biomass processing, enzyme immobilization, advancement in enzymes and bioprocess technology.

Enzyme catalysis, structure-function relations, Allosteric interactions

**SUGGESTED READING**

1. David L Nelson and Michael L Cox, Lehninger Principles of Biochemistry, 7<sup>th</sup> Ed., WH Freeman
2. Alejandro G. Marangoni. Enzyme Kinetics: A Modern Approach, 2003 Ed., John Wiley & Sons, Inc.
3. Huimin Zhao. Synthetic Biology Tools and Applications, 1<sup>st</sup>, Academic Press, Elsevier publishing.



**CIA-303**  
**ADVANCES IN ORGANIC AND MATERIAL CHEMISTRY**  
**2 credit course**

*This course is designed to give an overview regarding advances in organic and materials chemistry in order to apply the principles of organic, bio-organic, materials chemistry and nanotechnology in their research in the field of chemical sciences.*

**COURSE CONTENT**

**Selected reactions in organic chemistry**

Recent advances in selected metal-mediated coupling reactions and mechanisms: Suzuki, Sonogashira, Heck, and Stille coupling, selected familiar named reactions: Robinson annulation, Perkin reaction, Claisen condensation, Knoevenagel condensation, Mitsunobu reaction; Lewis acids and Lewis acid-catalyzed reactions; stereo-, chemo-, and regio-selective reactions, protective groups and their importance in synthetic organic chemistry.

**Selected topics of bio-organic chemistry**

Bio-catalysis, enzyme-catalyzed reactions, bio-organic related heterocycles, selected bio-organic molecules and their application, selected name reactions, rearrangements and mechanisms related to bio-organic chemistry.

**Special topics of materials chemistry**

Brief discussion about coordination chemistry, structure and bonding and their importance, acid and base reactions, stereochemistry basics, photochemistry overview, heterocyclic chemistry basics.

**Nanotechnology and its applications**

Major synthetic strategies: top down and bottom up approach, fundamentals, characterization techniques, scopes of nanomaterial applications in various fields including biomedicine.

**SUGGESTED READING**

1. F.A.Carey and R.J.Sundberg. Advanced Organic Chemistry Part A: Structure and Mechanism & Part B: Reactions and Synthesis, 5<sup>th</sup> Ed., Springer, New York.
2. W. Carruthers and I. Coldham. Modern Methods of Organic Synthesis, 4<sup>th</sup> Ed., Cambridge University Press.
3. F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann. Advanced Inorganic Chemistry, (Indian Edition), 6<sup>th</sup> Ed., Wiley-India, Noida.
4. J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi. Inorganic Chemistry: Principles of Structure and Reactivity (Indian Edition), 4<sup>th</sup> Ed., Pearson Education, India.
5. J. Clayden, N. Greeves, S. Warren and P. Wothers. Organic Chemistry, I Ed., Oxford University Press.

**CIA-304**  
**NATURAL PRODUCT CHEMISTRY**  
**2 credit course**

*This course aims to gain insight into carbohydrates and natural products chemistry. This course includes fundamental structures of carbohydrates, terpenoids, steroids, alkaloids and phenolics.*

**COURSE CONTENT**

**Carbohydrates**

Introduction to carbohydrates, classification of carbohydrates, structure of monosaccharides, disaccharides, chemistry of polysaccharides- cellulose and starch, potential transformation of carbohydrates.

**Terpenoids**

Introduction - structure and classification of terpenoids- geraniol,  $\alpha$ -pinene, camphor, zingiberene, farnesol and cadinene, application of terpenoids.

**Steroids and alkaloids**

Introduction, structure and classification of steroids and alkaloids - chemistry of cholesterol, testosterone, estrone, and progesterone, chemistry of quinine, nicotine and reserpine, and applications of steroids and alkaloids.

**Phenolics**

Introduction, definition, structure of coumarins, flavonoids, quinones, role in plants and applications

**SUGGESTED READING**

1. Michael L. Sinnott. Carbohydrate Chemistry and Biochemistry: Structure and Mechanism, 2<sup>nd</sup> Ed., RSC publishing.
2. Sujata V. Bhat, B.A. Nagasampagi, Meenakshi Sivakumar. Chemistry of Natural Products, Springer publishing, 2006.
3. Sukh Dev. Handbook of Terpenoids: Volume I: Triterpenoids, CRC press, 2018 reissue.

**CIA-305**  
**FOOD PROCESS TECHNOLOGY**  
**2 credit course**

*This course is designed to introduce the processing technologies in food science. The topics covered include the introduction to food processing, food fermentation, food technologies, and food preservation and packaging.*

**COURSE CONTENT**

**Introduction to food processing**

Introduction of food processing and preservation, food processing techniques: drying, freezing, blanching, sterilization, pasteurization and UHT processing, dielectric heating and canning.

**Food fermentation**

Fermentation technology, alcoholic beverage: classification and their production, non-distilled beverages, distilled alcoholic beverages, and fermented foods

**Food rheology and technologies**

Rheology of the food materials, milling technology: turbo milling, conventional wet and dry milling, baking technology, and extrusion technology.

**Food preservation and packaging**

Processing and preservation by non-thermal methods, food additives: permissible limits and safety aspects, biodegradable food films and coatings and applications, definitions, objectives and functions of packaging, packaging materials and food packaging system.

**Food bioprocessing**

Fundamentals of food biotechnology, application of biotechnology for food plant waste utilization (whey, molasses, starch substrates and others), waste treatment technologies: aerobic and anaerobic methods of treatment of food industry wastes, bioremediation, bioenergy, bio-conversion of food wastes to useful products.

**SUGGESTED READING**

1. V.K. Joshi. Biotechnology: Food Fermentation, volume I., Educational Publishers & Distributors.
2. S.S. Marwaha. Food Processing: Biotechnological Applications, Asiatech Publishers Inc. 2000.
3. E.J. Pyler. Bakery Science & Technology. Vols. I & II. Sosland Publisher.
4. N.D. Frame. The Technology of Extrusion Cooking, 1<sup>st</sup> Ed., Blackie Academic.
5. Neelam Khetar Paul and Darshan Punia. Food Packaging, Daya Publishing House, 2012.
6. Robertson. Food Packaging: Principles and Practice, 3<sup>rd</sup> Ed., Taylor and Francis publishing.

**CIA-306**  
**ADVANCES IN FOOD ENGINEERING**  
**2 credit course**

*This course is designed to acquaint with basic principles and advances of food engineering and processes. The topics covered include introduction to food engineering, fluid flow operations and rheology, membrane separation processing, and emerging processing technologies.*

**COURSE CONTENT**

**Introduction to food engineering**

Introduction to material & energy balance: principles, processes and operations.

**Fluid flow operations and rheology**

Important properties of fluids, factors affecting the rheological parameters, viscosity monitoring and control, transportation of fluids

**Membrane separation processing**

Theory of microfiltration, ultrafiltration and reverse osmosis, selection and types of membranes and properties, mathematical description of flow through membrane, application and use in food industry.

**Emerging process technologies**

Principles of radiation processing, microwave technology, ultrasonic technology, high pressure processing – principles, mechanism of action, advantages and disadvantages over conventional processing, equipment's and its applications in food industry, pulsed electric field processing, Ohmic heating of foods, high voltage pulse technique, aseptic processing, supercritical fluid extraction, nanotechnology: principles and application in food.

**SUGGESTED READING**

1. Toledo, R.M. Fundamentals of Food Process Engineering, 3<sup>rd</sup> Edition, Springer publishing.
2. Chandra, G.R. Essential of Food Process Engineering, BS Publications, 2006.
3. Das, H. Food Processing Operations Analysis, 1<sup>st</sup> Ed., Asian Books.
4. Smith, P.G. Introduction to Food Process Engineering, 2<sup>nd</sup> Ed., Springer publishing.
5. Fellows, P.J. Food Processing Technology: Principles and Practice, 4<sup>th</sup> Ed., Wood head publishing.
6. Barbosa-Canovas and Gustavo. Novel Food Processing Technologies, Marcel Dekker/CRC press, 2004.

**CIA-307**  
**PROCESS TECHNOLOGY**  
**2 credit course**

*The course is designed for developing concept of chemical engineering specifically on material balance, energy balance, fluid dynamics, mass transfer. This course also includes the knowledge on techno-commercial aspect of project management.*

**COURSE CONTENT**

**Basic introduction**

Introduction to chemical calculations, units, dimensions, chemical equation, stoichiometry, material balance fundamentals, energy balance concepts, units, enthalpy, heat of solution & mixing, humidity chart.

**Fluid mechanics**

Basic equation of fluid flow, Newtonian, non-Newtonian fluids, Reynolds's number, continuity equation, Bernoulli equation, fluid friction, flow in pipes, Hagen-Poiseuille equation, sudden expansion and contraction, transportation and metering of fluids.

**Heat transfer**

Heat transfer- conduction, Fourier's law, convection-forced & natural convection, radiation-Kirchhoff's law, Stefan-Boltzmann law, view factors, combined heat transfer, heat exchangers.

**Mass transfer**

Phase rule & phase diagram, azeotropes, distillation, leaching, adsorption, absorption, diffusion, process diagrams, distillation systems, separation systems.

**Project engineering**

Design calculations, P&ID, utility, valves, pumps, compressors, piping and vessels, techno feasibility concepts.

**SUGGESTED READING**

1. John M. Centanni and Michael J. Roy. Biotechnology Operations: Principles and Practices, 2<sup>nd</sup> Ed., CRC Press.
2. Nigel J Smart. Lean Biomanufacturing, Series No. 37, Wood head publishing, 2013.
3. Maggie Bryans, Linda Rehfuss. Introduction to Biomanufacturing, Northeast Biomanufacturing Center and collaboration, 2012.

**CIA-308**  
**CHEMICAL PROCESS DESIGN**  
**2 course credit**

*This course is designed to introduce the basic concepts of chemical reaction engineering and process design. The topics covered include the fundamentals of chemical reaction engineering, design of chemical reactors, ideal reactor systems, solid catalyzed reactions, and stoichiometry and process calculations.*

**COURSE CONTENT**

**Introduction to chemical engineering reaction**

Rate equation and rate controlling steps, elementary and non-elementary reactions, reaction rate and temperature dependency theories, design equation for constant.

**Chemical reactor design**

Variable volume batch reactors, analysis of experimental kinetics data, integral and differential analysis,

**Ideal reactor systems**

Homogeneous and heterogeneous reactor systems, design of reactors for multiple reactions - consecutive, parallel and mixed reactions, temperature and pressure effects.

**Solid catalyzed reactions**

Nature of catalysts, surface area and pore-volume distribution, catalyst preparation, rate equations for heterogeneous reactions, adsorption isotherms, rates of adsorption and desorption, surface reaction.

**Stoichiometry and process calculations**

Concept of material balance, material balances with and without chemical reactions, recycle operations, energy balances.

**SUGGESTED READING**

1. Levenspiel, O. Chemical Reaction Engineering, III Edition, John Wiley publishing.
2. Fogler. H. S. Elements of Chemical Reaction Engineering, III Edition. Prentice Hall of India publishing.
3. Richard M. Felder, Ronald W. Rousseau. Elementary Principles of Chemical Processes, III Ed. John Wiley and Sons.