PhD program in Biotechnology

Under

Regional Centre for Biotechnology, Faridabad

and

Center of Innovative and Applied Bioprocessing, Mohali

Center of Innovative and Applied Bioprocessing

(Dept of Biotechnology, Ministry of Science & Technology, Government of India)

Sector-81, Knowledge City, Mohali-140306, Punjab (INDIA)

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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

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

PhD COURSES

Semester – I		
Compulsory Course		
Course Code	**Subject**	**Credit (4)**
CIA-401	Research Methodology	2
CIA-402	Analytical Instrumentation	2
Elective Course		
Course Code	**Subject**	**Credit (4)**
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, 4th Ed. Thousand Oaks publishing.
2. C. R. Kothari. Research Methodology: Methods and Techniques, II Ed., New Age International.
3. Montgomary C. Douglas. Design and Analysis of Experiments, 5th Ed., Wiley India.
4. Krishnswamy, K.N., Shivkumar, Appa Iyer and Mathiranjan 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, 7th Ed., Wiley-Blackwell.
4. Jack Cazes. Analytical instrumentation handbook, 3rd 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. 4th Ed., Cold Spring Harbor.
2. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts and Peter Walter. Molecular Biology of the Cell, 7th 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 Vmax and Km) 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, 7th 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, 1st, 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, 5th Ed., Springer, New York.
2. W. Carruthers and I. Coldham. Modern Methods of Organic Synthesis, 4th Ed., Cambridge University Press.
3. F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann. Advanced Inorganic Chemistry, (Indian Edition), 6th 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), 4th 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, α-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, 2nd 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-conversation 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, 1st Ed., Blackie Academic.
5. Neelam Khetar Paul and Darshan Punia. Food Packaging, Daya Publishing House, 2012.
6. Robertson. Food Packaging: Principles and Practice, 3rd 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, 3rd Edition, Springer publishing.
2. Chandra, G.R. Essential of Food Process Engineering, BS Publications, 2006.
3. Das, H. Food Processing Operations Analysis, 1st Ed., Asian Books.
4. Smith, P.G. Introduction to Food Process Engineering, 2nd Ed., Springer publishing.
5. Fellows, P.J. Food Processing Technology: Principles and Practice, 4th 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-Poiseullie 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, 2nd 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.

