GENERAL INSTRUCTIONS
&
COURSE CURRICULUM

FOR

Ph.D. in Biotechnology
(Effective from Academic Session 2024-2025)

DEPARTMENT OF BIOTECHNOLOGY
HIMACHAL PRADESH UNIVERSITY
(NAAC Accredited "A" Grade University)
SUMMERHILL, SHIMLA-171005
HIMACHAL PRADESH, INDIA

GENERAL INSTRUCTIONS/GUIDELINES FOR EXECUTION OF CURRICULUM

1. All candidates admitted to the Ph.D. programme at the Department of Biotechnology have to complete a minimum of 12 credits.
2. There will be three (3) courses in Ph.D. Biotechnology Programme. The students have to take 2 compulsory courses **[RPE-PhD, PhDBIOTECH-101)]** and one additional course out of four **elective** courses **[PhDBIOTECH EL-102 (i -iv)]**.
3. A Ph.D. scholar must obtain a minimum of 55% marks in the course work to be eligible to continue in the programme and submit his or her thesis.
4. The detailed syllabi for the courses offered by the Department are appended with a list of suggested books.

Outline of the Course work for Ph.D. Biotechnology

Code	Title of Paper	Max Marks	Credits
RPE-PhD	Research and Publication Ethics (Common for all Ph.D. Students)	50	2
PhDBIOTECH-101	Research Methodology	100	5
Elective any one of the following *i.e.* PhDBIOTECH-102 (i-iv)			
PhDBIOTECH EL-102 (i)	Biotechnology for Bioprocess and Biobusiness	100	5
PhDBIOTECH EL-102 (ii)	Enzyme Technology	100	5
PhDBIOTECH EL-102 (iii)	Recombinant DNA Technology	100	5
PhDBIOTECH EL-102 (iv)	Bioinformatics & Artificial Intelligence	100	5
Total Marks/ Credits		**250**	**12**
The passing marks for Ph.D. Coursework will be 55% aggregate with minimum 50% in each individual course (All three courses).			

Ph.D. in Biotechnology (Compulsory Course)
Research and Publication Ethics
Course Code: RPE-PhD
(Common for all PhD students)

L	T	P	C
2	0	0	2

Theory Examination: 50 marks

Course description

This course has a total of 6 units focusing on the basics of philosophy of science and ethics, research integrity, and publication ethics. Hands-on sessions are designed to identify research misconduct and predatory publications. Indexing and citation databases, open-access publications, research metrics (citations, h-index, Impact Factor, etc.), and plagiarism tools will be discussed in this course.

Objectives

a. Promote the importance of research integrity.
b. Discuss the principles of publication ethics.
c. Educate on identifying research misconduct and predatory publishing.
d. Discuss indexing and citation databases.
e. Provide information on open-access publications and research metrics.
f. Introduce various plagiarism detection tools.

Evaluation

Continuous assessment will be conducted through tutorials, assignments, quizzes, and group discussions. At the end of the course, a final written examination of 50 Marks will be conducted.

1. Students who have at least 75% attendance in classes will be considered eligible for the final written examination.
2. The exam will be conducted for a three-hour duration.

Note for Paper Setting

There will be 7 questions covering all the units. The first six questions (1, 2, 3, 4, 5 & 6) of 6 marks each will consist of one question from each unit, with internal choice provided, meaning there will be two questions from each unit. The 7^{th} question will consist of 10 short answer type questions using Roman numerals (i, ii, iii,... x) each with 2 marks. There will be at least one question from each unit, and students will be required to attempt any seven questions out of ten.

Unit 01: Philosophy and Ethics

1. Introduction to philosophy: definition, nature and scope, concept, branches
2. Ethics: definition, moral philosophy, nature of moral judgments and reactions

Unit 02: Scientific Conduct

1. Ethics with respect to science and research
2. Intellectual honesty and research integrity
3. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP)
4. Redundant publications: duplicate and overlapping publications, salami slicing
5. Selective reporting and misrepresentation of data

Unit 03: Publication Ethics

1. Publication ethics: definition, introduction, and importance
2. Best practices/standards setting initiatives and guidelines: COPE, WAME, etc.
3. Conflicts of interest
4. Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types
5. Violation of publication ethics, authorship and contributorship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals

Unit 04: Open Access Publishing

1. Open-access publications and initiatives
2. SHERPA/ROMEO online resource to check publisher copyright & self-archiving policies
3. Software tool to identify predatory publications developed by SPPU
4. Journal finder/journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal, etc.

Unit 05: Publication Misconduct

A. Group Discussions

1. Subject-specific ethical issues, FFP, authorship
2. Conflicts of interest
3. Complaints and appeals: examples and fraud from India and abroad

B. Software tools

Use of plagiarism software like Turnitin, Urkund, and other open-source software tools

Unit 06: Databases and Research Metrics

A. Databases

1. Indexing databases
2. Citation databases: Web of Science, Scopus, etc.

B. Research Metrics

1. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score
2. Metrics: h-index, g index, i10 index, altmetrics

Suggested Readings

- Beall, J. (2012). Predatory publishers are corrupting open access. *Nature*, Vol. 489(7415), 179. https://doi.org/10.1038/489 l 79a.
- Bird, A. (2006). *Philosophy of Science*. Routledge.
- Bretag, Tracey (2016). *The Handbook of Academic Integrity*. Springer.
- Chaddah , P. (2018). *Ethics in Competitive Research: Do not get scooped; do not get Plagiarized*. ISBN:978-9387480865.
- Grudniewicz, Agnes, D. Moher, Kelly D. Cobey+32 authors (2019). Predatory journals: no definition, no defense. *Nature*, Vol. 576.
- Indian National Science Academy (2019). *Ethics in Science Education, Research and Governance* (2019). ISBN:978-81-939482-l- 7. http://www.insaindia.res.in/pdf/Ethics_Book.pdf
- Israel, Mark, Iain Hay (2006). *Research Ethics for Social Scientists.* London.
- Lang, James M. (2013). *Cheating Lessons: Learning from Academic Dishonesty*. Harvard University Press.
- MacIntyre, Alasdair (1967). *A Short History of Ethics*. London.
- National Academy of Sciences, National Academy of Engineering and Institute of Medicine. (2009). *On Being a Scientist: A Guide to Responsible Conduct in Research*. Third Edition. National Academies Press.
- Resnik, D. B. (2011). *What is ethics in research & why is it important*. National Institute of Environmental Health Sciences, 1-10. https://www.niehs.nih.gov/research/resources/bioethics/whatis /index.cfrn
- Whitley Jr., Bernard E. & Patricia Keith-Spiegel (2001). *Academic Dishonesty: An Educator's Guide*. Psychology Press.

Ph.D. in Biotechnology (Compulsory Course)
COURSE: PhDBIOTECH-101

RESEARCH METHODOLOGY

L	T	P	C
5	0	0	5

Theory: 60 Credit Hours ***Theory examination: 100 marks***

NOTE: Instructions for setting question paper

There will be eleven (11) questions covering all the units. The first ten (10) questions (1, 2,3….10) of explanatory answers of 12 marks each, will consist of two (2) questions from each unit. Student will be required to attempt one (1) question from each unit. Eleventh question will consist of ten (10) short answer type questions (i, ii, iii…….x) each with 5 marks covering the entire syllabus. Students will be required to attempt any eight (8) questions out of ten.

UNIT-I **(12 hours)**

Foundation of Research: Meaning, objectives of research; criteria of good research; basic steps of research; Qualitative and Quantitative Research.

Problem Identification & Formulation: selection of research problem.

Hypothesis: Qualities of a good Hypothesis, Null & Alternative Hypothesis, Hypothesis Testing, Logic & Importance

Review of Related Literature: Meaning, necessity and sources.

UNIT-II **(12 hours)**

Research process and Experiment Design: Concept and Importance in Research, features of a good research design, Exploratory Research Design concept, types and uses, Descriptive Research Designs concept, types and uses, Concept of Independent & Dependent variables.

Research Report: Writing preliminaries, main body of research, references and bibliography

Research and Development of Projects: Project formulation, National and international funding agencies for R & D projects, proposal submission, Intellectual Property Right (IPR).

UNIT-III **(12 hours)**

Sampling: Meaning and types of sampling; Probability and Non-Probability, Practical considerations in sampling and sample size.

Tools and Techniques of Data Collection: questionnaire, schedule, interview, observation, case study, survey *etc*. statistics and its significance in research.

Data Analysis: Frequency distribution, measures of central tendency, measures of dispersion, correlation, regression analysis, test of significance (Z-test, t-test, Chi-square test, F-test).

UNIT-IV **(10 hours)**

Use of Tools / Techniques for Research: Search engines: NCBI, PubMed, Google Scholar, Thomson Reuters, SCI etc, Reference Management Software like Zotero/Mendeley, Software for paper formatting like LaTeX/MS Office. Bioinformatics tools and applications.

UNIT-V **(14 hours)**

Bioanalytical tools: Centrifugation: differential, rate zonal and isopycnic centrifugation, Analytical and preparative ultracentrifuges. Chromatography: Paper, TLC, Gas chromatography, gel filtration, ion-exchange chromatography, reverse phase chromatography, hydrophobic interaction, affinity chromatography and HPLC. Electrophoresis: Gel electrophoresis, Immuno-electrophoresis, isoelectric focusing, two-dimensional electrophoresis. Spectrophotometry: UV & Visible spectroscopy, spectro-fluorimetry, atomic absorption and atomic emission spectroscopy, Florescent activated cell sorter (FACS). Molecular analysis**:** PCR, Primer designing, RFLP, RAPD, AFLP, DNA, RNA and protein sequencing, CRISPR/Cas-9 Technology.

Course objectives:

i. To provide basic framework and guidelines for researchers to clearly and define research problems, hypotheses, and objectives.
ii. To develop a deeper understanding of the principles involved behind the working of different instruments used in Biotechnology research.
iii. To make researchers able to utilize scientific learning for expanding their research aptitude

Course learning outcomes:

i. Will help the researchers to identify the most appropriate research design, sampling technique, and data collection and analysis methods.
ii. Researchers will be able to understand and comprehend the basics of research methodology and applying them in their research.
iii. Students will be able to learn all the basic and advanced techniques used in Biotechnology research.
iv. By using various tools, students will be able to identify, characterise, and quantify biomolecules with precision.

Suggested books [Latest Edition]:

1. Council of Biology Editors –CRE Style Manual, American Institute of Biological Sciences, Washington. D.C.
2. Effective Writing for Engineers, Managers, Scientists: Tichy AJ.
3. Scientific and Technical papers: Tribcase SF.
4. How to write and publish a scientific paper: Day RA.
5. Basic Biotechniques for Bioprocess and Bioentrepreneurship: Bhatt AK, Bhatia RK and Bhalla TC.
6. Principles and Techniques of Practical Biochemistry: Keith Wilson and John Walker.
7. Spectroscopy of Biological Molecules: Modern Trends: Carmona P, Navarro R and Hernanz A.

Ph.D. in Biotechnology (Elective Course)
COURSE: PhDBIOTECH EL-102 (i)

BIOTECHNOLOGY FOR BIOPROCESS AND BIOBUSINESS

L	T	P	C
5	0	0	5

Theory: 60 Credit Hours ***Theory examination: 100 marks***

NOTE: Instructions for setting question paper

There will be eleven (11) questions covering all the units. The first ten (10) questions (1, 2,3….10) of explanatory answers of 12 marks each, will consist of two (2) questions from each unit. Student will be required to attempt one (1) question from each unit. Eleventh question will consist of ten (10) short answer type questions (i, ii, iii……..x) each with 5 marks covering the entire syllabus. Students will be required to attempt any eight (8) questions out of ten.

UNIT-I (12 hours)

Bio-Process technology: Primary and secondary metabolites, integrated bio-process technology for products like baker's yeast, organic acids, enzymes and biofuels. Bio-process technology for the production of recombinant vaccines, therapeutic proteins and antibiotics, Monitoring and control of environmental parameters in fermentation process.

UNIT-II (12 hours)

Bioreactors and Bioreactor Control: Basic concepts of bioreactors, parameters of biochemical process, packed bed, fed-batch, bubble column, fluidized bed, trickle bed, CSTR, plug flow reactors, Innovative bioreactors, Reactor Dynamics and reactors with non-ideal characteristics**,** Manual and automatic control system, on-line and off-line analytical instruments, methods of measurement of process variables, Data analysis and process control.

UNIT-III (12 hours)

Kinetics of Sterilization and Scale-up Studies: Translation of laboratory, pilot and plant scale data, Criteria for translation between two scales of operation, Scale-up practices, Bases for scale-up methods, Comparison of various scale-up methods, Nongeometric scale-up. Kinetics of media sterilization, design of batch sterilization process, D-time, Z-value and F-value, calculation of Del-factor and holding time, Richards rapid method for design of sterilization cycles, Design of continuous sterilization, Air sterilization-design of air filters, Effect of air velocity and bed depth on filtration, single fibre efficiency.

UNIT-IV (12 hours)

Biosensors: Use of enzymes in analysis, biosensors- calorimetric, potentiometric, amperometric, optical, piezoelectric biosensors and immuno-sensors.

Economics of fermentation processes: Total product cost, capital investment and profitability, manufacturing cost estimation, capital investment estimation, Risk capital and working capital, cost analysis for R & D decision making.

UNIT-V (12 hours)

Biobusiness and Legal issues in Biotechnology: Concept of Bio-business management, Project formulation, business plan, technological Assessment, feasibility and commercial viability of a project.

Regulatory and IPR issues, Intellectual Property Rights (IPR), Licensing and Patenting of bio-product, GLP and GMP guidelines in fermentation processes.

Course objectives:

i. Technical know-how on versatile techniques in bioprocess technology.
ii. Will provide an understanding on application of bioprocess engineering techniques in basic and applied research.
iii. Will provide proficiency in designing and conducting fermentation studies.
iv. To provide basic knowledge to become next generation entrepreneurs.

Course learning outcomes:

i. Students will be able to learn the techniques of upstream & down-stream bio-process development, sterilization and scale up studies.
ii. Students will learn valuable skills for starting up of own company and be able to handle a broad range of tasks in life-science companies that develop and launch new products and services.

Suggested books [Latest edition]:

1. Bioprocess Engineering Principles: Pauline M Doran.
2. Principles of Fermentation Technology: Stanbury PF and Whitaker A.
3. Manual of Industrial Microbiology and Biotechnology: Demain AL and Solomon NA.
4. Basic Biotechniques for Bioprocess and Bioentrepreneurship: Bhatt AK, Bhatia RK and Bhalla TC.

Ph.D. in Biotechnology (Elective Course)
COURSE: PhDBIOTECH EL-102 (ii)

ENZYME TECHNOLOGY

L	T	P	C
5	0	0	5

Theory: 60 Credit Hours ***Theory examination: 100 marks***

NOTE: Instructions for setting question paper

There will be eleven (11) questions covering all the units. The first ten (10) questions (1, 2,3….10) of explanatory answers of 12 marks each, will consist of two (2) questions from each unit. Student will be required to attempt one (1) question from each unit. Eleventh question will consist of ten (10) short answer type questions (i, ii, iii……..x) each with 5 marks covering the entire syllabus. Students will be required to attempt any eight (8) questions out of ten.

UNIT-I (12 hours)

Introduction to enzyme and enzyme technology: History and scope of enzymes and enzyme technology, nomenclature of enzymes, enzyme activity units.

Sources and preparation of enzymes: Sources of enzymes, screening strategies for novel enzymes, media for enzyme production, methods of purification and concentration of intracellular and extracellular enzymes, factors affecting enzyme stability, preparation of enzymes for sale, customer service, safety and regulatory aspects of enzyme use

UNIT-II (12 hours)

Enzyme Kinetics: Activation Energy & Transition State concept. Mechanism of enzyme catalysis, simple kinetics of enzyme action, factors affecting enzyme activity, reversible reaction, enzyme inhibition, determination of Vmax and Km values.

UNIT-III (12 hours)

Enzyme immobilisation: Methods of immobilization of enzymes, kinetics of immobilized enzymes, effect of solute partition and diffusion on the kinetics of immobilized enzymes, use of immobilized enzymes, immobilized enzyme processes - production of high fructose corn syrups, production of antibiotics, production of acrylamide and use of immobilized invertase, lactase and raffinase.

UNIT-IV (12 hours)

Enzyme reactors: stirred tank reactors, plug flow reactors, continuous flow stirred tank fluidized bed reactor, Membrane/hollow fiber reactors.

Large Scale use of enzymes in solution: Use of enzymes in detergents, food industry, fruit juice, wine, brewing and distilling industries, textile industries, waste treatment, diagnostics, pharmaceutical and chemical industries, application of enzymes in medicine

UNIT-V (12 hours)

Advanced topics in enzyme technology: Enzyme reactions in biphasic liquid systems; proteases, glycosidases and lipases in synthetic reactions, interesterification of lipids, artificial enzymes, un-natural substrates, enzyme engineering, extremophilic enzymes, hybrid enzymes, high throughput screening and assay techniques.

Course objectives:

i. To inculcate the knowledge about different enzymes, characteristics and mechanism of action of enzymes, their kinetics and applications of enzymes that can benefit various sectors in society.

Course learning outcomes:

i. The students will be able to have in depth knowledge about the application of enzymes in the industry, research and pharmaceutical sciences.
ii. The students will able to assay the enzyme and their kinetics and also apply to this in the industry and other technological fields and will also be able to purify enzymes and use the same for the benefit of the mankind
iii. Will be able to understand about the process for commercialization of any biotechnological products developed with the use of specific enzymes.

Suggested books [Latest edition]:

1. Enzyme Technology: Chaplin MF and Bucks DC.
2. Industrial Enzymology: Godfrey and West.
3. Enzyme: Copeland
4. Enzymes in Industry: Gerhartz W

Ph.D. in Biotechnology (Elective Course)
COURSE: PhDBIOTECH EL-102 (iii)

RECOMBINANT DNA TECHNOLOGY

L	T	P	C
5	0	0	5

Theory: 60 Credit Hours ***Theory examination: 100 marks***

NOTE: Instructions for setting question paper

There will be eleven (11) questions covering all the units. The first ten (10) questions (1, 2,3….10) of explanatory answers of 12 marks each, will consist of two (2) questions from each unit. Student will be required to attempt one (1) question from each unit. Eleventh question will consist of ten (10) short answer type questions (i, ii, iii……..x) each with 5 marks covering the entire syllabus. Students will be required to attempt any eight (8) questions out of ten.

UNIT-I **(12 hours)**

Recombinant DNA: Basics and scope of Recombinant DNA Technology enzymes that break, mend and synthesize DNA and RNA backbone bonds, remove phosphates at nucleic acid termini, and proteins which protect, coat, twist and untwist DNA. Isolation of DNA, RNA and Plasmid

UNIT-II **(12 hours)**

Cloning and expression vectors: Characteristics of cloning and expression vectors; plasmid, phage and cosmid vectors, multipurpose cloning vectors, shuttle vectors; bacterial, yeast, plant and mammalian expression vectors.

DNA Cloning Strategies: Preparation of genomic and cDNA libraries, criteria for selection of cloning vectors - plasmid, bacteriophage and cosmid, transformation and transfection, electroporation, screening of gene library and selection of clone.

UNIT-III **(12 hours)**

Expression of cloned genes: Expression of cloned genes in *E. coli*, *Bacillus subtilis*, *Streptomyces*, yeast and mammalian cells, detection and analysis of proteins expression from cloned genes.

Nucleic acid Blotting and Hybridization: Southern and northern blotting and hybridization techniques, radioactive and non-radioactive labelling of probe, western blotting.

UNIT-IV **(12 hours)**

Polymerase chain reaction and site directed mutagenesis: Principle and application of polymerase chain reaction, site-directed mutagenesis and protein engineering, molecular markers.

Sequencing and other techniques: DNA, RNA and protein sequencing, DNA finger and foot printing, CRISPR/Cas-9 technology, antisense RNA.

UNIT-V **(12 hours)**

Impact of rDNA on human genetics: DNA based diagnosis, gene targeting, human genome project history and scope, ethical issues in relation to rDNA technology.

Applications of r-DNA technology: Application of genetic engineering in industry, agriculture, medicine, environment and forensic science

Course objectives:

i. To make students understand the basics of tools and techniques used in manipulation and analysis of DNA.
ii. A sound knowledge of the subject will help students to apply these tools in their research.

Course learning outcomes:

i. Students will be able to understand the principles of genetic manipulation; isolation of total genomic DNA, restriction and ligation of DNA molecules, amplifying recombinant DNA, molecular cloning, bacterial transformation
ii. Students also gain an insight as to how genetic engineering is used to provide innovative solutions to the societal challenges.

Suggested books [Latest Edition]:

1. Recombinant DNA Principles and Methodologies: James J Greene.
2. Molecular Biotechnology: Glick and Pasternak.
3. Principles of Gene Manipulation: Old RW and Primrose SB.
4. Genetic Engineering Fundamentals: Kammermeyer and Clark.
5. Gene Cloning and DNA Analysis: Brown TA

Ph.D. in Biotechnology (Elective Course)
COURSE: PhDBIOTECH EL-102 (iv)

BIOINFORMATICS AND ARTIFICIAL INTELLIGENCE

L	T	P	C
5	0	0	5

Theory: 60 Credit Hours ***Theory examination: 100 marks***

NOTE: Instructions for setting question paper
There will be eleven (11) questions covering all the units. The first ten (10) questions (1, 2,3….10) of explanatory answers of 12 marks each, will consist of two (2) questions from each unit. Student will be required to attempt one (1) question from each unit. Eleventh question will consist of ten (10) short answer type questions (i, ii, iii……..x) each with 5 marks covering the entire syllabus. Students will be required to attempt any eight (8) questions out of ten.

UNIT-I **(12 hours)**

Bioinformatics: Introduction to NCBI website, NCBI Genome, and Swiss-Prot, Databases, Restriction endonuclease mapping, Comparison of sequences using Basic Local Alignment Search Tool (BLAST), Local Alignment using L-Align, Global Alignment using MatGAT, Multiple Alignment using Clustal, Construction of phylogenetic trees, Gene prediction, Comparison and analysis of whole genomes

(12 hours)

UNIT-II

Molecular modelling: Introduction, molecular mechanics and dynamics, dynamic simulation, conformational search, molecular modelling packages (Chem3D, Hyperchem), protein modelling, structure prediction and molecular docking. Role in drug designing and synthetic biology, QSAR, Simulation of biochemical reactions, Modelling of enzymatic catalysis

UNIT-III **(12 hours)**

Protein engineering: Directed Laboratory Evolution and Rational Protein Designing: Concepts, strategies and applications. High-throughput Screening Methodologies: Bacteriophage display, Bacterial cell surface display, Yeast display, m-RNA display, Ribosome display, Cis-display, DNA-display and water in-oil emulsions.

UNIT-IV **(12 hours)**

Basics of Artificial Intelligence: Overview of AI technologies used in biotech, Machine learning algorithms in biotech, Neural networks and deep learning in biotech, Ethical and legal implications of AI in biotech, Data privacy and security concerns in AI-powered biotech

UNIT-V **(12 hours)**

AI in Biotechnology: Applications of AI in the pharmaceutical industry, drug design, clinical trials, precision and Personalized medicine, medical imaging, monitoring health and disease, synthetic biology, transforming Agriculture with AI, Industrial process optimisation, AI and renewable energy, Human-AI interfaces

Course objectives:

i. To make students understand the basics of bioinformatics and to develop analytical ability in molecular modelling.
ii. Learning of Artificial Intelligence in various Biotech & health sector.

Course learning outcomes:

i. Students will be able to understand basic bioinformatics software and programs
ii. Student will be able to grasp the AI knowledge and its role in human welfare

Suggested books [Latest Edition]:

1. Bioinformatics: Methods and Applications Genomics Proteomics and Drug Discovery: Rastogi SC, Mendiratta N, Rastogi P.
2. Protein Engineering: Principles and Practice: Jeffrey L. Cleland and Charles S. Craik.
3. Artificial Intelligence and Biotechnology: The Golden Age of Medical Research. Kumar U and Gupta KK.
4. Artificial Intelligence in Biotechnology: Preethi Kartan.