Ph.D. (Biosciences) Course Work Syllabus

Effective from July 2025

Subject Code	Subject Title	Credit	Hours of Teaching	External Marks	Internal Marks	Total Marks
BIOCW 101	Research Methodology and Computational Approaches in Life Sciences	4	60	50	50	100
BIOCW102	Communication Skills, Research and Publication Ethics	4	60	50	50	100
BIOCW103 BO	Advances in Botany	4	60	50	50	100
BIOCW103 MB	Advances in Microbiology					
BIOCW103 ZO	Advances in Zoology					
BIOCW103 BT	Advances in Biotechnology					
Total	-	**12**	**180**	**150**	**150**	**300**

Instruction for Students:

All enrolled students must complete the following:

Compulsory Papers: BIOCW 101 & BIOCW 102

Elective Paper: From the four available options under BIOCW 103, each student must choose any one paper that aligns with their M.Sc. specialization.

Note: Lectures for each paper will be conducted as per the assigned credits and hours. Wherever applicable, practical demonstrations will also be included based on the syllabus of the respective paper.

Program Outcomes (POs) for Ph.D. Course Work (Biosciences)

PO1: Knowledge and Comprehension (Bloom's: Remember & Understand)

Demonstrate in-depth understanding of foundational and advanced concepts in biosciences, including research methodology, communication skills, and recent advances in subject-specific domains such as Botany, Zoology, Microbiology, or Biotechnology.

PO2: Research Planning and Execution (Bloom's: Apply & Analyze)

Design and implement scientifically sound research protocols using appropriate experimental design, data collection strategies, and analytical tools including statistical and computational approaches.

PO3: Critical Thinking and Problem Solving (Bloom's: Analyze & Evaluate)

Critically evaluate scientific problems using evidence-based reasoning, synthesize information from multiple sources, and formulate innovative solutions to contemporary issues in biosciences, health, agriculture, or environment.

PO4: Ethical and Responsible Research Practice (Bloom's: Understand & Evaluate)

Exhibit integrity and adherence to ethical norms in all aspects of research—ranging from data management and authorship to publication and intellectual property protection.

PO5: Communication and Scholarly Dissemination (Bloom's: Understand & Create)

Demonstrate the ability to effectively communicate scientific knowledge through research writing, oral presentations, and preparation of publishable review articles or case studies aligned with global academic standards.

PO6: Multidisciplinary and Translational Research Approach (Bloom's: Apply & Create)

Integrate multidisciplinary tools such as artificial intelligence, biotechnology, and systems biology into bioscience research to create translational outcomes with societal, industrial, and environmental relevance.

PO7: Lifelong Learning and Scientific Leadership (Bloom's: Evaluate & Create)

Cultivate the mindset of a lifelong learner and scientific leader, capable of mentoring, adapting to emerging research trends, and contributing to national and global research agendas like SDGs and One Health.

PSO Code	Program Specific Outcome Statement
PSO1	Apply domain-specific knowledge (Botany, Zoology, Microbiology, Biotechnology) to design, conduct, and interpret original research contributing to advancements in life sciences.
PSO2	Demonstrate interdisciplinary competencies by integrating computational, biotechnological, and ecological tools to address real-world challenges.
PSO3	Practice ethical research conduct and communicate scientific findings effectively through publications, proposals, patents, or presentations.
PSO4	Lead and contribute to national/international scientific agendas with a commitment to sustainability, translational impact, and lifelong learning.

PO–PSO Mapping Matrix

Mapping Matrix	PSO1	PSO2	PSO3	PSO4
PO1: Knowledge and Comprehension	✓	✓	✓	
PO2: Research Planning and Execution	✓	✓		✓
PO3: Critical Thinking and Problem Solving	✓	✓		✓
PO4: Ethical and Responsible Research Practice			✓	✓
PO5: Communication and Scholarly Dissemination	✓		✓	✓
PO6: Multidisciplinary and Translational Approach	✓	✓	✓	✓
PO7: Lifelong Learning and Scientific Leadership		✓	✓	✓

BIOCW 101: Research Methodology and Computational Approaches in Life Sciences

- **Credits: 4 (Total 60 Hours)**
- **Semester: Ph.D. Coursework Semester – I**
- **Applicable Disciplines: Botany, Zoology, Microbiology, Biotechnology**

Course Objectives

CO Code	Course Outcome	Bloom's Level	Mapped Program Outcomes (POs)
CO1	Understand various research paradigms, design research questions and proposals.	Understand, Create	PO1, PO2
CO2	Execute well-structured experiments with appropriate sampling and data capture methods.	Apply	PO2, PO3
CO3	Apply biostatistical tools for analysis and decision-making.	Apply, Evaluate	PO2, PO3
CO4	Employ AI tools to support literature analysis, data generation, and interpretation.	Analyze, Apply	PO3, PO6
CO5	Integrate modern methods to develop research pipelines in respective disciplines.	Create	PO3, PO6, PO7

Course Learning Outcomes

CLO Code	Learning Objective Statement	Bloom's Level	Mapped (COs)
CLO1	To introduce scholars to the philosophy and paradigms of scientific research in life sciences.	Understand	CO1
CLO2	To enable scholars to formulate research questions, hypotheses, and SMART objectives relevant to their discipline.	Understand, Create	CO1
CLO3	To train scholars in designing experiments with appropriate sampling, controls, and standard protocols.	Apply	CO2
CLO4	To develop the ability to generate and manage biological data using modern experimental and computational methods.	Apply, Analyze	CO2 & CO5
CLO5	To provide working knowledge of key bioinformatics databases, tools, and software platforms used in life science research.	Apply, Analyze	CO4 & CO5
CLO6	To equip scholars with statistical skills for hypothesis testing, data interpretation, and graphical presentation.	Apply, Evaluate	CO3
CLO7	To introduce and promote the use of Artificial Intelligence and Machine Learning tools in life science research planning, literature review, and data analysis.	Analyze, Create	CO4
CLO8	To facilitate integration of domain-specific computational approaches for developing novel research pipelines.	Create	CO5

Unit 1: Research Foundations and Conceptualization in Life Sciences

1.1 Types and Philosophy of Research: Qualitative vs quantitative, applied vs basic, translational research. Interdisciplinary and ethical paradigms.

1.2 Research Problem and Question Formulation: Problem identification, hypothesis setting, SMART objectives, variables.

1.3 Literature Review and Information Gathering: Search strategies, databases (PubMed, Scopus), AI tools (Elicit, ResearchRabbit), citation tools.

1.4 Linking Research to SDGs and Societal Needs: Mapping objectives to SDGs, research with impact, One Health approach.

1.5 Subject-Specific Research Planning Cases (Botany/Zoology/Microbiology/Biotech): Proposal mini-cases for real-world alignment.

References

1. Kumar, R. (2014). Research methodology: A step-by-step guide for beginners (4th ed.). New Delhi: SAGE Publications.
2. Kothari, C. R., & Garg, G. (2019). Research methodology: Methods and techniques (4th ed.). New Delhi: New Age International Publishers.
3. Aruni, A. W., & Ramadass, P. (2009). Research methods for life sciences. Chennai: MJP Publishers.
4. Creswell, J. W., & Creswell, J. D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.). New Delhi: SAGE Publications India.

Unit 2: Experimental Design, Data Generation & Modern Methods in Life

2.1 Experimental Design and Protocol Planning: Randomization, replication, factorial designs, SOPs, GLP, error control.

2.2 Sampling Techniques and Data Collection: Field/lab methods, types of sampling, biological/technical replicates.

2.3 High-Throughput Data Generation Techniques: Genomics, transcriptomics, proteomics, metabolomics; automation.

2.4 Introduction to Bioinformatics Tools and Databases: NCBI, UniProt, BLAST, Cytoscape, Galaxy, KEGG.

2.5 Subject-Specific Experimental Applications: Cloning, MIC assays, GPS-tracking in zoology, chlorophyll imaging in plants.

References

1. Liebler, D. C. (2002). Introduction to proteomics: Tools for the new biology. Totowa, NJ: Humana Press.
2. Baxevanis, A. D., & Ouellette, B. F. F. (2005). Bioinformatics: A practical guide to the analysis of genes and proteins (3rd ed.). New Delhi: Wiley India.
3. Mount, D. W. (2004). Bioinformatics: Sequence and genome analysis (2nd ed.). New Delhi: Pearson Education.
4. Arthur M. Lesk (2014), Introduction to Bioinformatics(4th ed,)Oxford University Press. ISBN: 978-0-19-965156-6
5. David A. Hendrix(2019)Applied Bioinformatics, Oregon State University.

Unit 3: Biostatistics Fundamentals for Life Sciences

3.1 Types of Data and Descriptive Statistics: Nominal to ratio scale, mean/SD/SE/CV, visualizations.
3.2 Probability Distributions and Hypothesis Testing: Normal/binomial/Poisson, p-values, errors, tails.
3.3 Correlation and Regression Analysis: Pearson/Spearman, linear regression, ANOVA, biological interpretation.
3.4 Introduction to Statistical Software Tools: R, SPSS, GraphPad, visualization, reproducibility.
3.5 Discipline-Specific Statistical Applications: Biotech IC50 estimation, Microbial growth, PlantEcophys, Animal behaviour.

References

1. Daniel, W. W. (2010). Biostatistics: A foundation for analysis in the health sciences (9th ed.). New Delhi: Wiley India.
2. Zar, J. H. (2014). Biostatistical analysis (5th ed.). Delhi: Pearson Education.
3. Khan, I. A., & Khanum, A. (2004). Fundamentals of biostatistics (2nd ed.). Hyderabad: Ukaaz Publications.

Unit 4: Artificial Intelligence for Data Collection and Analysis

4.1 Fundamentals of AI and ML in Life Sciences: Supervised vs unsupervised, classification, DL, ethical AI.
4.2 AI Tools for Research Planning and Literature Review: ChatGPT, Scite, Semantic Scholar, citation trees.
4.3 AI for Biological Sequence, Image & Text Analysis: Protein modeling (AlphaFold), gene predictions, microscopy image classification.
4.4 Integration of AI in Bioinformatics and Drug Discovery: DeepChem, QSAR, CRISPR guide design, omics prediction.
4.5 Subject-Specific AI Use Cases: AI for root image analysis, species identification, AMR prediction, gene networks.

References

1. Aggarwal, C. C. (2018). Machine learning for text and data analysis. Cham: Springer International Publishing.
2. Achuthsankar, S. N. (2009). Bioinformatics: A primer. New Delhi: Tata McGraw Hill.
3. Mishra, N. C. (2018). Artificial intelligence in biology and medicine. New Delhi: Alpha Science Intl Ltd.
4. Pattanayak, S. (2017). Mastering machine learning with R. Mumbai: Packt Publishing.

BIOCW102: Communication Skills, Research and Publication Ethics

- **Credits: 4 (Total 60 Hours)**
- **Semester: Ph.D. Coursework Semester – I**
- **Applicable Disciplines: Botany, Zoology, Microbiology, Biotechnology**

Course Objectives:

CO Code	Course Outcome Statement	Bloom's Level	Mapped Program Outcomes (POs)
CO1	Demonstrate proficiency in scientific writing, academic communication, and presentation techniques.	Understand, Apply	PO5, PO7
CO2	Apply advanced research communication strategies for international publication and visibility.	Apply, Create	PO5, PO6, PO7
CO3	Exhibit ethical responsibility in research conduct, authorship, and publication processes.	Understand, Evaluate	PO4, PO7
CO4	Identify, avoid, and address research misconduct and predatory publishing practices.	Evaluate	PO4
CO5	Understand and apply the fundamentals of IPR to safeguard research innovations and support commercialization.	Understand, Apply	PO4, PO6

Course Learning Outcomes:

CLO Code	Learning Objective Statement	Bloom's Level	Mapped Course Outcomes (COs)
CLO1	To develop understanding of communication types and their significance in scientific and academic settings.	Understand	CO1, CO2
CLO2	To train scholars in academic writing, record keeping, referencing, and research manuscript preparation.	Apply, Create	CO1, CO2
CLO3	To sensitize scholars to the ethical responsibilities in research and publication practices.	Understand, Evaluate	CO3, CO4
CLO4	To introduce tools and guidelines for identifying plagiarism, predatory journals, and publication misconduct.	Evaluate	CO4
CLO5	To create awareness on IPR and legal frameworks that protect research outcomes.	Understand, Apply	CO5
CLO6	To build skills for preparing research proposals, delivering oral/poster presentations, and engaging in peer review.	Apply, Create	CO1, CO2

Unit 1: Philosophy and Ethics, Scientific Conduct, Publication Ethics

1.1: **Philosophy and Ethics**: Introduction to philosophy: definition, nature and scope, concept, branches. Ethics: definition, moral philosophy, nature of moral judgements and reactions

1.2: **Scientific Conduct**: Ethics with respect to science and research, Intellectual honesty and research integrity, Scientific misconduct: Falsification, Fabrication, and Plagiarism (FFP)

1.3: **Redundant publications**: duplicate and overlapping publications, salami slicing, Selective reporting, and misrepresentation of data

1.4: **Publication Ethics**: Publication ethics: definition, introduction and importance, Best practices/standards setting initiatives and guidelines: COPE, WAME, etc., Conflicts of interest,

1.5: **Publication misconduct**: definition, concept, problems that lead to unethical behaviour and vice versa, types, Violation of publication ethics, authorship and contributorship, Identification of publication misconduct, complaints and appeals, Predatory publishers and journals

References:

1. Bird, A. (2006). *Philosophy of science*. Routledge.
2. MacIntyre, Alasdair (1967). *A Short History of Ethics*. London.
3. P. Chaddah (2018). *Ethics in Competitive Research: Do not get scooped; do not get plagiarized.* ISBN: 978-9387480865
4. 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.
5. Resnik, D. B. (2011). What is ethics in research & why is it important. *National Institute of Environmental Health Sciences*, 1–10. Retrieved from: https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm
6. Beall, J. (2012). Predatory publishers are corrupting open access. *Nature*, 489(7415), 179–179. https://doi.org/10.1038/489179a
7. Indian National Science Academy (INSA) (2019). *Ethics in Science Education, Research and Governance.* ISBN: 978-81-939482-1-7 http://www.insaindia.res.in/pdf/Ethics_Book.pdf
8. Petter Laake, Haakon Breien Benestad and Bjorn Reino Olsen (2007), Research Methodology in the Medical and Biological Sciences, 978-0-12-373874-5
9. Cargill, M., & O'Connor, P. (2013). Writing Scientific Research Articles: Strategy and Steps (2nd ed.). Oxford: Wiley-Blackwell.
10. Nielsen, J. (2019). Effective Communication Skills. New York: Independently Published.
11. Katz, M. J. (2006). From Research to Manuscript: A Guide to Scientific Writing. New York: Springer.

Unit 2: Open Access Publishing, Publication Misconduct, Databases and Research Metrics

1.1: Open access publishing: open access publications and initiatives, SHERPA/ROMEO online resource to check publisher copyright & self-archiving policies

1.2: Software tools to identify predatory publications developed by SPPU, journal finder / journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc.

1.3: Publication misconduct: Group discussions: Subject-specific ethical issues, Authorship, Conflicts of interest, Complaints and appeals: examples and fraud from India and abroad. **software tools**: use of plagiarism software like Turnitin, Orkund (Original), and other open-source software tools

1.4: Databases and research metrics: Databases: Indexing databases, citation databases: web of science, Scopus, etc.

1.5 Research metrics: impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score, Metrics: h-index, g-index, i10-index, Altmetrics

References:

1. Petter Laake, Haakon Breien Benestad and Bjorn Reino Olsen (2007), Research Methodology in the Medical and Biological Sciences, 978-0-12-373874-5
2. Suber, P. (2012). Open Access. MIT Press.
3. Resnik, D. B. (2020). The Ethics of Research with Human Subjects: Protecting People, Advancing Science, Promoting Trust. Springer.
4. Björk, B.-C. (2017). Open access to scientific articles: A review of benefits and challenges. Internal and Emergency Medicine, 12(2), 247–253.
5. SHERPA/RoMEO – Check publisher self-archiving policies:, https://openpolicyfinder.jisc.ac.uk/
6. SPPU (Savitribai Phule Pune University) – Predatory Journal Identification Tool https://sppupredjournalchecker.unipune.ac.in/
7. Moher, D., Shamseer, L., Cobey, K. D., Lalu, M. M., Galipeau, J., Avey, M. T., ... & Ziai, H. (2017). Stop this waste of people, animals and money. *Nature*, *549*(7670), 23-25.
8. JANE (Journal/Author Name Estimator) https://jane.biosemantics.org/
9. Elsevier Journal Finder. https://journalfinder.elsevier.com/
10. Springer Journal Suggester. https://journalsuggester.springer.com/

Unit 3: Understanding Communication, Essential Communication Skills, Recording and managing information, Writing a research proposal, research paper and PhD thesis

1.1: Understanding Communication: Process, Role, and Importance, Types of Communication: Intrapersonal, Interpersonal, Group, Public, Mass, and Non-verbal Communication

1.2: The essential features of scientific communication, Referencing, The writing process: Planning, writing, revising, Interpersonal communication

1.3: Maintaining experimental records of research data, Managing your e-mail: some simple guidelines, Organizing electronic and hard copy information

1.4: Writing a PhD thesis: Requirements, Structure and content, Thesis by published papers format, Strategy for writing your thesis, The viva.

1.5: Citation

References:

1. Centre for Good Governance. (2013). Handbook on Communication Skills. Hyderabad: Centre for Good Governance.

2. Cargill, M., & O'Connor, P. (2013). Writing Scientific Research Articles: Strategy and Steps (2nd ed.). Oxford: Wiley-Blackwell.
3. James E. Mauch & Namgi Park (2003) Guide to the successful Thesis and Dissertation,Fifth Edition, MARCEL DEKKERINC.,NEW YORK • BASEL, ISBN: 0-8247-4288-5
4. Nielsen, J. (2019). Effective Communication Skills. New York: Independently Published.
5. Katz, M. J. (2006). From Research to Manuscript: A Guide to Scientific Writing. New York: Springer.
6. Ayesha Divan (2009) Communication skill for the biosciences - A graduate guide, Oxford university press, ISBN: 9780199226351

Unit 4: Delivering effective oral presentations, Preparing and presenting a research poster

1.1: Components of research proposal, writing the proposal, and Funding sources for biosciences research, Peer review and outcome of your application, Annotated example of a research proposal

1.2: Structure, Strategy for writing, aim and typical content, Submitting a completed manuscript, Peer review and publication of Research Paper

1.3: Delivering effective oral presentations: Introduction, The oral presentation-an overview, planning your presentation, preparing your presentation, Practicing your presentation, Delivering your presentation, Evaluating your presentation

1.4: Preparing and presenting a research poster: Poster preparations, Planning, Preparing, at the poster presentation session, after the presentation.

1.5: Multidisciplinary research

References:

1. Brause, R. S. (2000). Writing Your Doctoral Dissertation: Invisible Rules for Success. New York: RoutledgeFalmer.
2. Wager, E., & Kleinert, S. (2011). Responsible Conduct of Research. London: Sense About Science.
3. Oliver, P. (2010). The Student's Guide to Research Ethics (2nd ed.). Maidenhead: Open University Press.
4. Janice R. Matthews and Robert W. Matthews (2008), Successful Scientific Writing, ISBN:0-511-35454-1
5. University Grants Commission (UGC). (2020). Guidelines for Research and Publication Ethics. New Delhi: UGC.

BIOCW103 BO: Advances in Botany

- **Credits: 4 (Total 60 Hours)**
- **Semester: Ph.D. Coursework Semester – I**
- **Applicable Disciplines: Botany**

Course Outcomes

CO Code	Course Outcome Statement	Bloom's Level	Mapped Program Outcomes (POs)
CO1	Explain and integrate knowledge of plant systems and their relevance to health, agriculture, and sustainability.	Understand, Analyze	PO1, PO6
CO2	Apply innovative technologies (e.g., metagenomics, diagnostics, genome editing) to solve real-world biological problems.	Apply, Create	PO2, PO3, PO6
CO3	Analyze genome data, diagnostic markers, and physiological pathways relevant to drug discovery and sustainable crops.	Analyze, Evaluate	PO3, PO6
CO4	Evaluate biological synthesis of nanomaterials using a multidisciplinary approach within a One Health framework.	Evaluate, Create	PO3, PO6, PO7
CO5	Develop scientific reviews or case studies based on critical appraisal of contemporary literature.	Create	PO1, PO5, PO7

Course Learning Objectives

CLO Code	Learning Objective Statement	Bloom's Level	Mapped Course Outcomes (COs)
CLO1	To build foundational knowledge of plant stress physiology, defense, allelopathy, and plant-microbe interactions.	Understand, Analyze	CO1
CLO2	To understand and apply modern tools (GPS, GIS, omics) in studying plant-environment interactions.	Apply, Analyze	CO1, CO2
CLO3	To apply phytochemical and nanotechnology-based techniques for therapeutic and agricultural applications.	Apply, Create	CO2, CO4
CLO4	To analyze and evaluate functional genomics, gene editing, AI, and synthetic biology applications in crop improvement.	Analyze, Evaluate, Create	CO2, CO3
CLO5	To evaluate the role of advanced tissue culture and bio-based nanomaterials in plant propagation and sustainability.	Evaluate, Apply	CO3, CO4
CLO6	To develop skills in literature review and scientific writing through independent study and guided review preparation.	Create	CO5

Unit-1 Plant Physiology and Stress Biology

1.1 **Plant responses to abiotic stress**: Drought, salinity, heat, heavy metals. Molecular and physiological mechanisms of stress tolerance. Transcriptomics and proteomics in plant stress responses. Modern techniques and tools for stress ecological studies- GPS, GIS and remote sensing for vegetation mapping.

1.2 **Plant defence:** Systemic Acquired Resistance (SAR), role of Elicitor molecules, Signal Perception and Transduction.

1.3 **Allelopathy:** Allelopathy and its applications in weed management, Allelochemical-root exudates, volatiles, tree allelopathy in agroforestry, examples of invasive plant species on native biodiversity.

1.4 **Plant-microbe interactions:** PGPR, Biofertilizer, Biopesticides, Crop rotation.

References:

1. Plant Stress Physiology by Sergey Shabala, Academic Press, 2nd Ed., 2021, ISBN: 9780128192022.
2. Plant Physiology by Taiz & Zeiger, Sinauer Associates, 5th Ed., 2010, ISBN: 9780878938667.
3. Plant Omics: The Omics of Plant Science by Debmalya Barh, Springer, 1st Ed., 2013, ISBN: 9781461481481.
4. Remote Sensing of Vegetation by Hamlyn G. Jones, Academic Press, 1st Ed., 2011, ISBN: 9780123869714.
5. GIS and Remote Sensing Applications in Biogeography and Ecology by Andrew C. Millington, Springer Nature, 1st Ed., 2012, ISBN: 978-1-4613-5596-0.
6. Biochemistry and Molecular Biology of Plants by Buchanan, Gruissem & Jones, Wiley Blackwell, 2nd Ed., 2015, ISBN: 9780470714216.
7. Allelopathy by Elroy L. Rice, Academic Press, 2nd Ed., 1983, ISBN: 9780125870559.
8. Principles of Plant-Microbe Interactions by Ben Lugtenberg, Springer, 1st Ed., 2015, ISBN: 9783319085746.

Unit-2 Phytochemistry & Herbal Biotechnology

2.1 **Secondary metabolites in plants**: Alkaloids, Flavonoids, Terpenoids, Saponins, Phenols and tannins -their types and biological function.

2.2 **Bioprospecting of novel therapeutic compounds:** Atropine, caffeine, ephedrine, opioids, taxol, vinca alkaloids, Quinine, Artemisinin. Drug improvement by structure. Phytoequivalence& pharmaceutical equivalence. WHO guidelines for assessment of herbal drugs.

2.3 **Biological Synthesis of Nanomaterials:** Biological synthesis of nanoparticles using plants. Silver nanoparticles, gold nanoparticles, cerium oxide nanoparticles, titanium oxide and zinc oxide nanoparticles.

2.4 **Structural Characterization of Nanomaterials:** X-ray diffraction, Electron microscopy- Scanning Electron Microscopy (SEM), Transmission Electron Microscopy-(TEM) including highresolution imaging, FTIR- XPS. Surface characterization: atomic force microscopy (AFM).

References:

1. Secondary Metabolism in Microorganisms, Plants and Animals by M. Luckner, Springer, 1984, ISBN 9783662098400.
2. Pharmacognosy and Phytochemistry by Vinod D. Rangari, 2nd Ed., Career Publications, 2009, ISBN: 8188739650.
3. WHO Monographs on Selected Medicinal Plants by World Health Organization, WHO, 1st Ed., 1999, ISBN: 9789241545179.
4. Nanobiotechnology in Agriculture by K.K. Patel et al..
5. Characterization of Nanomaterials in Complex Environmental and Biological Media by J. E. Hutchison.
6. Scanning Electron Microscopy and X-ray Microanalysis by Joseph Goldstein.

Unit-3 Plant Biotechnology in Agriculture Improvement

3.1 **Functional genomics in crop improvement**: CRISPR/Cas9 another genome editing tools (ZFNs, TALENs) in plants. Case studies: Use of CRISPR/Cas9 to develop disease-resistant rice or drought-tolerant maize. Tools used in functional genomics: microarrays, RNA-seq, TILLING, and gene knockout approaches. Gene expression profiling.

3.2 **Synthetic biology and artificial intelligence in crop improvement**: Machine learning and AI in plant phenotyping. Designing novel gene circuits, metabolic engineering, and synthetic pathways. Applications in creating biosensors, synthetic promoters, and novel traits (e.g., nitrogen fixation in cereals). Applications in high-throughput plant phenotyping: automated detection of stress, growth rate, and yield components. Use of 3D plant imaging and modelling: LiDAR, hyperspectral imaging, and deep learning in morphological analysis. Integration of omics data (genomics, proteomics, phenomics) using AI tools for predictive breeding.

3.3 **Biofortification:** Enhancing nutritional quality via genetic engineering, overexpression of transporter genes, pathway modification (e.g., carotenoid pathway in Golden Rice, Other examples of iron-rich beans, zinc-fortified wheat, role of cisgenic and transgenic techniques in biofortification.

3.4 **Micropropagation & Advanced Tissue Culture Technologies:** Hormone interaction-traditional auxins/cytokinins vs. novel regulators (meta-topolin, brassinosteroids, jasmonic/salicylic acid) and their effects on recalcitrant species and regeneration efficiency, Photoautotrophic tissue culture: sugar-free media, ventilated lids, CO_2 enrichment to reduce hyperhydricity, accelerate growth. Nanotechnology-Enhanced Culture Media: **Iron oxide nanoparticles (FeO-NPs), Fe_3O_4-NPs, metal NPs** (Ag, Au, Zn, Ti, Si, Co, etc.) improves organogenesis, somatic embryogenesis, secondary metabolism, protoplast transformation, and cryopreservation. **Bio-based nanoparticles** (cellulose, chitosan, lignin) enhance nutrient uptake, disease resistance-as elicitor, stress resilience, root development. Robotics & automation in media prep, explant handling, plantlet culture.

References:

1. Plant Biotechnology and Genetics by C. Neal Stewart Jr., Wiley-Blackwell, 2nd Ed., 2016, ISBN: 9781118889022.
2. Genome Editing in Plants by Om Prakash Dhankher, Springer, 1st Ed., 2021, ISBN: 9783030601571.
3. Synthetic Biology in Agriculture and Food Production by Pallaval Veera Bramhachari.
4. Artificial Intelligence in Agriculture by Jatinder Singh et al..
5. Biofortification of Staple Crops by Shiv Kumar et al..
6. Plant Tissue Culture: Theory and Practice by S.S. Bhojwani and M.K. Razdan.
7. Nanotechnology and Plant Sciences by Manzer H. Siddiqui.

Unit-4: Review or Case Study Preparation (1 Credit)

This unit is designed to develop the ability of PhD scholars to critically analyze scientific literature and prepare scholarly Review or Case Study aligned with their research domain. The process will encourage independent learning under faculty/ Guide supervision and prepare candidates for high-quality scientific writing and publication.

Course Content & Guidelines

1. **Selection of Literature (Syllabus Definition):**
   - Each PhD guide will select at least five (5) review articles from Clarivate (Web of Science) or Scopus-indexed reputed journals, related to the candidate's research topic. These five articles will constitute the syllabus for this unit, and scholars are expected to study them thoroughly.
2. **Critical Appraisal:**
   - Candidates will analyze the selected articles in terms of research trends and methodologies, identification of knowledge gaps and relevance to their doctoral work.
3. **Review Preparation:**

- Each scholar will prepare a comprehensive review article on their PhD topic under the guidance of their respective supervisor by following ethical writing standards and referencing guidelines.

4. **Assessment Components:**
   - Theory Examination (50%): Based on the five selected review articles.
   - Assignment (50%): Preparation and submission of a review article as an internal assignment.

References:

1. Bahl, M. (2023). A Step-by-Step Guide to Writing a Scientific Review Article. *Journal of Breast Imaging*, *5*(4), 480-485.
2. Dhillon, P. (2022). How to write a good scientific review article. *The FEBS Journal*, *289*(13), 3592-3602.
3. Chatterjee, K., Davies, G. L., Engqvist, H., & Winter, J. (2025). Writing an impactful Review: top tips from the Editors. *Journal of Materials Chemistry B*, *13*(13), 4041-4044.
4. Bahl, M. (2023). A Step-by-Step Guide to Writing a Scientific Review Article. *Journal of Breast Imaging*, *5*(4), 480-485.
5. Dhillon, P. (2022). How to write a good scientific review article. *The FEBS Journal*, *289*(13), 3592-3602.
6. Biodiversity and Conservation by Michael J. Jeffries.
7. Restoration Ecology: The New Frontier by Jelte van Andel & James Aronson.
8. Ethnobotany: Principles and Applications by C.M. Cotton, John Wiley & Sons, 1st Ed., 1996, ISBN: 9780471498931.
9. Medicinal Plants: Ethnobotany and Conservation by N. P. Singh.
10. How to Write and Publish a Scientific Paper by Barbara Gastel and Robert A. Day, Cambridge University Press, 9th Ed., 2022, ISBN: 9781316510687.

BIOCW103 MB: Advances in Microbiology

- **Credits: 4 (Total 60 Hours)**
- **Semester: Ph.D. Coursework Semester – I**
- **Applicable Disciplines: Microbiology**

Course Outcomes

CO Code	CO Code	CO Code	CO Code
CO1	Explain and integrate knowledge of microbial diversity (e.g., extremophiles, microbiomes) and their applications.	Understand, Analyze	PO1, PO6
CO2	Apply microbial technologies (e.g., metabolomics, diagnostics, synthetic biology, genome editing) to real-world issues.	Apply, Create	PO2, PO3, PO6
CO3	Analyze traditional microbial knowledge systems (IKS), AMR, and environmental issues using advanced microbiological tools.	Analyze, Evaluate	PO3, PO6
CO4	Evaluate microbial roles in bioremediation, circular economy, and waste valorization within a One Health framework.	Evaluate, Create	PO3, PO6, PO7
CO5	Develop scholarly review or case study based on critical appraisal of scientific literature.	Create	PO1, PO5, PO7

Course Learning Objectives

CLO Code	Learning Objective Statement	Bloom's Level	Mapped Course Outcomes (COs)
CLO1	To understand the diversity, adaptability, and ecological role of microorganisms, including extremophiles and microbiomes.	Understand, Analyze	CO1
CLO2	To explore the concept of circular economy and AMR through microbial approaches aligned with One Health.	Understand, Evaluate	CO1, CO4
CLO3	To apply and evaluate microbial tools in diagnostics, waste valorization, and environmental sustainability.	Apply, Evaluate	CO2, CO4
CLO4	To develop expertise in metabolomics, synthetic biology, and systems biology for microbial applications.	Apply, Create	CO2, CO3
CLO5	To analyze and integrate Indian Knowledge Systems (e.g., Panchagavya, Jeevamrut) into modern microbiological science.	Analyze, Evaluate	CO3
CLO6	To independently conduct literature analysis and write a comprehensive review/case study in their research domain.	Create	CO5

Unit 1: Microbial Systems and Strategies for Health, Environment, and Sustainability

1.1 **Introduction, Adaptation, Application of Extremophiles**: Acidophilic, Alkaliphiles, Halophiles, Psychrophiles, thermophiles and Hyperthermophiles

1.2 **Human & Environmental Microbiomes**: Introduction and analysis, Gut, Oral, Skin, Vaginal and Respiratory Microbiome, Integrative Human Microbiome Project, Environmental Microbiomes: Ocean, Soil and Plant microbiome

1.3 **Culturomics**: Approach in studying the roles of human and animal microbiota

1.4 **Circular economy**: Introduction, Framework for implementing Circular economy, Methods for recycling and valorization of agricultural waste biomass, Agri-residue Generation and Co-firing of biomass

1.5 **AMR and One health**: Introduction, Types and Mechanisms Drug Resistance, Strategies and Next-Generation Antimicrobials to Contain AMR. Drivers of AMR, Recent Approaches for Downplaying AMR, AMR: A One Health Perspective

References

1. Koki Horikoshi & William D. Grant, 1998. Extremophiles: Microbial Life in Extreme Environments, ISBN: 978-0-471-02618-1
2. Dylan Parks, 2022 Microbiomes: Health and the Environment, MAVS OPEN PRESS, ISBN 978-1-64816-002-8
3. Howe, S., Liu, Z., Zuo, B., & Zhao, J. (2024). Culturomics: A critical approach in studying the roles of human and animal microbiota. Animal Nutriomics, 1, e6.
4. E.K. Radhakrishnan, R. Aswani, Ajay Kumar, 2024. The Potential of Microbes for a Circular Economy, ISBN 9780443159244
5. Ashok K Rathoure, Shashwat Katiyar, Harish Chandra and Rupesh Kumar Luhariya, 2021. Sustainable Practices for Waste Management, ISBN-9789388854665
6. Tang, K. W. K., Millar, B. C., & Moore, J. E. (2023). Antimicrobial resistance (AMR). *British journal of biomedical science*, *80*, 11387.
7. Belay, W. Y., Getachew, M., Tegegne, B. A., Teffera, Z. H., Dagne, A., Zeleke, T. K., ... & Aschale, Y. (2024). Mechanism of antibacterial resistance, strategies and next-generation antimicrobials to contain antimicrobial resistance: A review. Frontiers in Pharmacology, 15, 1444781.
8. Irfan, M., Almotiri, A., & AlZeyadi, Z. A. (2022). Antimicrobial resistance and its drivers—a review. *Antibiotics*, *11*(10), 1362.
9. Ahmed, S., Ahmed, M. Z., Rafique, S., Almasoudi, S. E., Shah, M., Jalil, N. A. C., & Ojha, S. C. (2023). Recent approaches for downplaying antibiotic resistance: molecular mechanisms. BioMed Research International, 2023(1), 5250040.
10. McEwen, S. A., & Collignon, P. J. (2018). Antimicrobial resistance: a one health perspective. *Antimicrobial resistance in bacteria from livestock and companion animals*, 521-547.

Unit 2 Microbial Innovations from Traditional Roots to Technological Frontiers

1.1 Microorganisms and climate change

1.2 **Microbiology in IKS**: Ancient Indian contribution to Microbiology, Early microbial practices in India, Pioneers in Indian microbiology, Microbes in Indian culture and religion, Panchagavya-based microbial formulations, Jeevamrut, Beejamrit and organic farming

1.3 System biology and Synthetic biology for microbial production of commodity chemicals, Principles of Holobionts and Hologenomes

1.4 **Metabolomics**: New software tools, databases, and resources, Bioinformatics Workflow for Metabolomics Analysis, Advances in high throughput LC/MS based metabolomics and NMR based metabolomics, Potential of Metabolomics in Biomedical Applications

1.5 **Nanobiotechnology**: Nanomaterials, types and application, Physical, Chemical, Biological and Self-assembly methods for nanomaterials synthesis

References

1. Cavicchioli, R., Ripple, W. J., Timmis, K. N., Azam, F., Bakken, L. R., Baylis, M., ... & Webster, N. S. (2019). Scientists' warning to humanity: microorganisms and climate change. *Nature Reviews Microbiology*, *17*(9), 569-586.
2. Sanjo S. Thomas, 2023, Microbial Mysteries of India : India's rich legacy in Microbiology, ISBN 9789358689167
3. Bajaj, K. K., Chavhan, V., Raut, N. A., & Gurav, S. (2022). Panchgavya: A precious gift to humankind. Journal of Ayurveda and integrative medicine, 13(2), 100525.
4. Mukherjee, S., Sain, S., Ali, M. N., Goswami, R., Chakraborty, A., Ray, K., ... & Chatterjee, G. (2022). Microbiological properties of Beejamrit, an ancient Indian traditional knowledge, uncover a dynamic plant beneficial microbial network. *World Journal of Microbiology and Biotechnology*, *38*(7), 111.
5. Bhadu, K., Rathore, R. S., & Shekhawat, P. S. (2023). Jeevamrut and panchagavya's consequences on growth, quality and productivity of organically grown crops: A review. Agricultural Reviews, 44(4), 451-459.
6. Saharan, B. S., Tyagi, S., Kumar, R., Vijay, Om, H., Mandal, B. S., & Duhan, J. S. (2023). Application of Jeevamrit improves soil properties in zero budget natural farming fields. Agriculture, 13(1), 196.
7. Gurjar, R. P. S., Bhati, D., & Singh, S. K. (2024). Impact of Jeevamrut formulations and biofertilizers on soil microbial and chemical attributes during potato cultivation. J. Appl. Biol. Biotechnol, 12(4), 158-171.
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9. Chubukov, V., Mukhopadhyay, A., Petzold, C. J., Keasling, J. D., & Martín, H. G. (2016). Synthetic and systems biology for microbial production of commodity chemicals. *NPJ systems biology and applications*, *2*(1), 1-11.
10. Garner, K. L. (2021). Principles of synthetic biology. *Essays in biochemistry*, *65*(5), 791-811.
11. Misra, B. B. (2021). New software tools, databases, and resources in metabolomics: Updates from 2020. *Metabolomics*, *17*(5), 49.
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13. Plumb, R. S., Gethings, L. A., Rainville, P. D., Isaac, G., Trengove, R., King, A. M., & Wilson, I. D. (2023). Advances in high throughput LC/MS based metabolomics: A review. *TrAC Trends in Analytical Chemistry*, *160*, 116954.
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15. Gonzalez-Covarrubias, V., Martínez-Martínez, E., & del Bosque-Plata, L. (2022). The potential of metabolomics in biomedical applications. *Metabolites*, *12*(2), 194.
16. Bordenstein, S. R., & Theis, K. R. (2015). Host biology in light of the microbiome: ten principles of holobionts and hologenomes. PLoS biology, 13(8), e1002226.
17. Sulabha K. Kullkarni, Nanotechnology Principles and Practices, Second Edition, Capital Publishing company ISBN- 81-85589-54-2.
18. Sharon, M., Sharon, M., & Pandey 2013, Bionanotechnology concept and application, Ane Books, Pvt. Ltd. ISBN: 978-93-8116-236-1
19. An introduction to Nanotechnology, A. Rathinasamy, C. Parameswari and V. Ponnuswami, New India Publishing Agency, ISBN: 978-93-81450-41-3

Unit 3: Bioprocess and Translational Microbiology

1.1 Bioprocess Technology: Isolation, screening and strain improvement of microorganisms. Polyphasic concept in Microbial identification. Fermentation-Solid state and Submerged,

Fermenter: Components and types, upstream and downstream processing, Immobilized cell system- Active and passive immobilization, Bioreactors for immobilized cell culture, Biofilms reactors.

1.2 **Drug discovery and development**: Process and key stages

1.3 **Advanced Diagnostics methods**: Genotyping and molecular marker in Diagnostic bacteriology- Molecular marker, Nucleic acid-based typing, biotyping, optical map typing, Pulsotyping, Sequence typing.

1.4 **Bacterial Genome Project**: NGS technologies, Genome Sequencing Strategies, Gene annotation, WGS, 100K & 100,000 genome project, Human Microbiome Project, Plasmid sequencing project, RNA Genome project. MDR Bacteria Genome Editing: Conventional Genome Editing, Editing by Targetron and recombinases and by Engineered Nucleases, ZFN and TALEN. Genome Editing in MDR bacterial species: CRISPR and Modified CRISPR, Identification of Cas9and Application of genome editing.

1.5 **Microbiology at field:** Various Phases of Wastewater Technologies and trends and future perspectives, Solid waste and their sustainable management practices, Bioremediation and biodegradation technologies for removal of pollutants and wastes, Bioleaching- recovery of metals, MICP- Microbiological and Molecular Concepts

References

1 P F Stanbury, A Whitaker & S. J. Hall, 2017. Principles of Fermentation Technology, 3rd Ed. ISBN: 978-0080999531

2 Bergey's Manual of Systematic Bacteriology Second Edition, Volume One, 2001, Springer ISBN 978-1-4419-3159-7

3 Sibi G. 2019. Industrial Microbiology and Biotechnology, ISBN: 978-93-5299-150-8 (HPH)

4 Kristian Strømgaard, Povl Krogsgaard-Larsen, Ulf Madsen, 2017, Textbook of Drug Design and Discovery, Fifth Edition, CRC press, ISBN: 978-1-4987-0278-2
Smarnika Pattnaik, 2021. Diagnostic Bacterial Genomics, ISBN: 9789352735471

5 Fernandes, J., Ramísio, P. J., & Puga, H. (2024). A Comprehensive Review on Various Phases of Wastewater Technologies: Trends and Future Perspectives. Eng, 5(4), 2633-2661.

6 Ashok K Rathoure, Shashwat Katiyar, Harish Chandra and Rupesh Kumar Luhariya, 2021. Sustainable Practices for Waste Management, ISBN-9789388854665

7 Ronald M. Atlas, Richard Bartha, 1997, 4th edition Microbial Ecology: Fundamentals and Applications, ISBN: 978-0805306552

8 Castro-Alonso, M. J., Montañez-Hernandez, L. E., Sanchez-Muñoz, M. A., Macias Franco, M. R., Narayanasamy, R., & Balagurusamy, N. (2019). Microbially induced calcium carbonate precipitation (MICP) and its potential in bioconcrete: microbiological and molecular concepts. Frontiers in Materials, 6, 126.

Unit 4: Review or Case Study Preparation (1 Credit)

This unit is designed to develop the ability of PhD scholars to critically analyze scientific literature and prepare scholarly Review or Case Study aligned with their research domain. The process will encourage independent learning under faculty/ Guide supervision and prepare candidates for high-quality scientific writing and publication.

Objectives

- To enable scholars to identify and critically analyze contemporary literature relevant to their research.
- To strengthen scientific writing and critical appraisal skills.
- To prepare scholars for publishing in reputed peer-reviewed journals.
- To assess their ability to understand and synthesize complex scientific information.

Course Content & Guidelines

1. **Selection of Literature (Syllabus Definition):**
    - Each PhD guide will select at least five (5) review articles from Clarivate (Web of Science) or Scopus-indexed reputed journals, related to the candidate's research topic.

These five articles will constitute the syllabus for this unit, and scholars are expected to study them thoroughly.

2. **Critical Appraisal:**
   - Candidates will analyze the selected articles in terms of research trends and methodologies, identification of knowledge gaps and relevance to their doctoral work.
3. **Review Preparation:**
   - Each scholar will prepare a comprehensive review article on their PhD topic under the guidance of their respective supervisor by following ethical writing standards and referencing guidelines.
4. **Assessment Components:**
   - Theory Examination (50%): Based on the five selected review articles.
   - Assignment (50%): Preparation and submission of a review article as an internal assignment.

Reference

1. Bahl, M. (2023). A Step-by-Step Guide to Writing a Scientific Review Article. *Journal of Breast Imaging*, *5*(4), 480-485.
2. Dhillon, P. (2022). How to write a good scientific review article. *The FEBS Journal*, *289*(13), 3592-3602.
3. Chatterjee, K., Davies, G. L., Engqvist, H., & Winter, J. (2025). Writing an impactful Review: top tips from the Editors. *Journal of Materials Chemistry B*, *13*(13), 4041-4044.

BIOCW103 ZO: Advances in Zoology

- **Credits: 4 (Total 60 Hours)**
- **Semester: Ph.D. Coursework Semester – I**
- **Applicable Disciplines: Zoology**

Course Outcomes

CO Code	Course Outcome Statement	Bloom's Level	Mapped Program Outcomes (POs)
CO1	Explain and integrate knowledge of animal models and their relevance to health, agriculture, and environmental sustainability.	Understand, Analyze	PO1, PO6
CO2	Apply advanced technologies (e.g., metagenomics, genome editing, AI, diagnostics) to address biological problems.	Apply, Create	PO2, PO3, PO6
CO3	Analyze genome data, diagnostic markers, and breeding strategies for producing sustainable animal systems.	Analyze, Evaluate	PO3, PO6
CO4	Evaluate drug action and resistance mechanisms using integrated, multidisciplinary approaches in a One Health framework.	Evaluate, Create	PO3, PO6, PO7
CO5	Develop scholarly reviews or case studies based on critical appraisal of relevant literature in zoology and related fields.	Create	PO1, PO5, PO7

Course Learning Objectives

CLO Code	Learning Objective Statement	Bloom's Level	Mapped Course Outcomes (COs)
CLO1	To understand the principles of toxicology and explore the utility of animal models in biomedical research and drug discovery.	Understand, Analyze	CO1, CO4
CLO2	To apply digital and molecular tools in modern taxonomy, wildlife tracking, and animal breeding.	Apply, Analyze	CO2, CO3
CLO3	To evaluate advanced breeding and reproductive technologies including transgenesis, IVF, cryopreservation, and sexed semen.	Evaluate, Apply	CO3
CLO4	To investigate drug action, resistance pathways, and nanotechnology-enabled diagnostics in animal health and biotechnology.	Analyze, Evaluate, Create	CO2, CO4
CLO5	To understand ethical frameworks and national/international guidelines for animal and human research.	Understand, Evaluate	CO4
CLO6	To independently develop review papers or case studies relevant to zoological sciences through critical literature analysis.	Create	CO5

Unit-1 Toxicology and Drug discovery

1.1 Principles of Toxicology: Classes of toxicants, Dose response relationship, rout of exposure, mechanism of toxicity.
1.2 Animal toxicity test: Acute toxicology, repeated dose toxicology, chronic toxicology, reproductive toxicology, developmental toxicology and genotoxicology,
1.3 Animal Models in biomedical research Zebrafish, Drosophila, Artemia, Daphnia, mice, C. elegance as an Animal Model
1.4 Natural products from animal sources: Bioactive compounds from invertebrates and vertebrates, pharmacological significance of animal derived peptides and alkaloids, drug discovery and development: Process and key stages
1.5 Mechanism of drug action and resistance: Target identification, drug receptor interaction and signalling pathways, mechanism of resistance, **High throughput screening and computational tools:** Bioinformatic tools in, Nanotechnology in drug delivery and diagnostics.

References:

1. Casarett & Doull's Essentials of Toxicology (2022), 4th Edition by McGraw Hill.
2. Introduction top toxicology By John Timberll 3rd Edition (2002), Taylor and Francis Group: http://ndl.ethernet.edu.et/bitstream/123456789/32288/1/John%20Timbrell%20%20.pdf
3. Scientific consideration and Choice of species (2008) World Scientific Publishing Company: https://www.vet.k-state.edu/research/student-opportunities/vet-scholar/calendar/pdf/The%20Rationale%20For%20The%20Use%20Of%20Animal%20Models%20in%20Biomedical%20Research.pdf
4. Text Book of Drug Discovery: https://bcrti.co.in/digitallibrary/includeFolder/noticeFolder/21082811424054.pdf

Unit-2 Morden animal taxonomy & Animal Breeding

2.1 Molecular taxonomy, DNA barcoding, phylogenetics, integrated taxonomy, epigenetics
2.2 Digital taxonomy: online databases (GBIF, ITIS, NCBI, etc.)
2.3 Use of GPS, GIS, and remote sensing in wildlife studies.
2.4 Animal Breeding: In and out-breeding, Open nucleus system, concept of production of Specific Pathogen Free (SPF) animals and vaccine production using SPF animals.
2.5 Advanced Techniques in animal breeding: Transgenesis, Cloning, Artificial Insemination (AI), Embryo Transfer technology (ETT), Sexed Semen technology, In Vitro Fertilization (IVF), cryopreservation of gametes and embryo.

References:

1. Molecular Taxonomy: An Approach Based on Molecular Markers: https://www.researchgate.net/publication/259449876_Molecular_Taxonomy_An_Approach_Based_on_Molecular_Markers#fullTextFileContent
2. Singh, A. K. (2012). Molecular taxonomy: use of modern methods in the identification of a species. Indian Journal of Life Sciences, 2(1), 143-147. https://www.ijls.in/upload/394213364PAPER_31.pdf
3. Molecular taxonomy – Applications, Limitations and future, Sandhya Sukumaran and A. Gopalakrishnan (2015)
4. Integrated Taxonomic Information System (ITIS): https://www.itis.gov/
5. NCBI Taxonomy Database: https://www.ncbi.nlm.nih.gov/taxonomy
6. Global Biodiversity Information Facility (GBIF): https://www.gbif.org/
7. AnimalBase: http://www.animalbase.org/
8. Textbook Animal Breeding and Genetics (second edition, 2024), https://wiki.groenkennisnet.nl/space/TAB

9. Hall, J. B., & Glaze, J. B. (2014). Sexed semen-How it is produced and how can we use it efficiently. In *Proceedings of the 2014 Applied Reproductive Strategies in Beef Cattle Conference* (pp. 215-230). https://beefrepro.org/wp-content/uploads/2020/09/Hall_John.pdf
10. Shakweer, W. M. E., Krivoruchko, A. Y., Dessouki, S. M., & Khattab, A. A. (2023). A review of transgenic animal techniques and their applications. *Journal of Genetic Engineering and Biotechnology*, *21*(1), 55.
11. Sexed Semen :An overview, https://www.dairyknowledge.in/dkp/article/sexed-semen-overview
12. Cryopreservation Methods and Frontiers in the Art of Freezing Life in Animal Models: https://www.intechopen.com/chapters/79909
13. Cryopreservation of Semen in Domestic Animals: A Review of Current Challenges, Applications, and Prospective Strategies: https://pmc.ncbi.nlm.nih.gov/articles/PMC9739224/

Unit-3 Animal Biotechnology & Ethics

3.1 **Recombinant DNA technology**: tools and techniques. **Transgenic animals:** methods of production (microinjection, retroviral vectors, CRISPR/Cas9) and application of transgenic animals.
3.2 **Animal genome projects**: cattle, poultry, pig. **Molecular markers:** RFLP, AFLP, RAPD, SSR, SNP and Marker-assisted selection in livestock improvement.
3.3 **Human and other animal Microbiomes: Introduction and analysis, Gut, Oral, Skin, Vaginal and Respiratory Microbiome, Integrative Human Microbiome Project.**
3.4 **Diagnostic tools:** PCR, qPCR, ELISA, Biosensors, AI in animal science
3.5 **Guidelines for animal research:** CPSEA and international regulations, Animal ethical committee, Human ethical committee, Biosafety committee

References:

1. Microbiomes: Health and the Environment by Dylan Parks (2022, CC BY) https://open.umn.edu/opentextbooks/textbooks/microbiomes-health-and-the-environment?utm_source=chatgpt.com
2. The role of microbiomes in animal invasions: a scoping review" (Romeo et al., 2025, NeoBiota) DOI: 10.3897/neobiota.98.145939
3. "Engineering the microbiome for animal health and conservation" (Song et al., 2019, Experimental Biology and Medicine) https://www.researchgate.net/publication/331201723_Engineering_the_microbiome_for_animal_health_and_conservation
4. "Advances in Microbiome Research for Animal Health" https://www.annualreviews.org/content/journals/10.1146/annurev-animal-091020-075907
5. Institutional Animal Care and committee Guideline (2002) 2nd Edition, Office of Laboratory Animal Welfare (OLAW) National Institutes of Health
6. CPCSEA Standard Operating Procedures (SOP) for IAEC (2010)
7. National Ethical Guidelines for Biomedical And Health Research Involving Human Participants (2017), Indian Council of Medical Research (ICMR)
8. HANDBOOK for INSTITUTIONAL BIOSAFETY COMMITTEES (IBSCs) (2020), Department of Biotechnology, Ministry of Science & Technology, Government of India, 3rd Edition

Unit 4: Review or Case Study Preparation (1 Credit)

This unit is designed to develop the ability of PhD scholars to critically analyze scientific literature and prepare scholarly Review or Case Study aligned with their research domain. The process will encourage independent learning under faculty/ Guide supervision and prepare candidates for high-quality scientific writing and publication.

Course Content & Guidelines

1. **Selection of Literature (Syllabus Definition):**
   - Each PhD guide will select at least five (5) review articles from Clarivate (Web of Science) or Scopus-indexed reputed journals, related to the candidate's research topic. These five articles will constitute the syllabus for this unit, and scholars are expected to study them thoroughly.
2. **Critical Appraisal:**
   - Candidates will analyze the selected articles in terms of research trends and methodologies, identification of knowledge gaps and relevance to their doctoral work.
3. **Review Preparation:**
   - Each scholar will prepare a comprehensive review article on their PhD topic under the guidance of their respective supervisor by following ethical writing standards and referencing guidelines.
4. **Assessment Components:**
   - Theory Examination (50%): Based on the five selected review articles.
   - Assignment (50%): Preparation and submission of a review article as an internal assignment.

Reference

1. Bahl, M. (2023). A Step-by-Step Guide to Writing a Scientific Review Article. *Journal of Breast Imaging*, *5*(4), 480-485.
2. Dhillon, P. (2022). How to write a good scientific review article. *The FEBS Journal*, *289*(13), 3592-3602.
3. Chatterjee, K., Davies, G. L., Engqvist, H., & Winter, J. (2025). Writing an impactful Review: top tips from the Editors. *Journal of Materials Chemistry B*, *13*(13), 4041-4044.

BIOCW103 BT: Advances in Biotechnology

- **Credits: 4 (Total 60 Hours)**
- **Semester: Ph.D. Coursework Semester – I**
- **Applicable Disciplines: Biotechnology**

Course Outcomes

CO Code	Course Outcome Statement	Bloom's Level	Mapped Program Outcomes (POs)
CO1	Explain and integrate knowledge of animal models and their applications in biotechnology, health, and sustainability.	Understand, Analyze	PO1, PO6
CO2	Apply genome editing, diagnostics, bioinformatics, and synthetic biology techniques to solve applied biological problems.	Apply, Create	PO2, PO3, PO6
CO3	Analyze genome data, molecular markers, and breeding technologies for crop and livestock improvement.	Analyze, Evaluate	PO3, PO6
CO4	Evaluate biotechnological innovations in drug resistance mechanisms and One Health strategies.	Evaluate, Create	PO3, PO6, PO7
CO5	Develop scientific reviews or case studies from critical analysis of literature in biotechnology.	Create	PO1, PO5, PO7

Course Learning Objectives

CLO Code	Learning Objective Statement	Bloom's Level	Mapped Course Outcomes (COs)
CLO1	To understand the biology and biotechnological relevance of animal models and microbiomes in research and development.	Understand, Analyze	CO1
CLO2	To apply recombinant DNA technology and transgenic tools such as CRISPR/Cas9 in genome editing and functional genomics.	Apply, Create	CO2, CO3
CLO3	To analyze plant and animal biotechnology techniques including tissue culture, biofortification, and breeding innovations.	Analyze, Evaluate	CO2, CO3
CLO4	To evaluate nanotechnology, synthetic biology, and artificial intelligence in drug discovery and environmental applications.	Evaluate, Create	CO2, CO4
CLO5	To understand biosafety and ethical guidelines applicable to biotechnology research involving transgenics and diagnostics.	Understand, Evaluate	CO4
CLO6	To independently review scientific literature and produce a review or case study in a relevant biotechnology domain.	Create	CO5

Unit-1 Animal Biotechnology & Ethics

1.1 **Recombinant DNA technology**: tools and techniques. **Transgenic animals:** methods of production (microinjection, retroviral vectors, CRISPR/Cas9) and application of transgenic animals.

1.2 **Animal genome projects**: cattle, poultry, pig. **Molecular markers:** RFLP, AFLP, RAPD, SSR, SNP and Marker-assisted selection in livestock improvement.

1.3 **Human and other animal Microbiomes:** Introduction and analysis, Gut, Oral, Skin, Vaginal and Respiratory Microbiome, Integrative Human Microbiome Project.

1.4 **Diagnostic tools:** PCR, qPCR, ELISA, Biosensors, AI in animal science

1.5 **Guidelines for animal research:** CPSEA and international regulations, Animal ethical committee, Human ethical committee, Biosafety committee

References:

1. Microbiomes: Health and the Environment by Dylan Parks (2022, CC BY) https://open.umn.edu/opentextbooks/textbooks/microbiomes-health-and-the-environment?utm_source=chatgpt.com
2. The role of microbiomes in animal invasions: a scoping review" (Romeo et al., 2025, NeoBiota) DOI: 10.3897/neobiota.98.145939
3. "Engineering the microbiome for animal health and conservation" (Song et al., 2019, Experimental Biology and Medicine) https://www.researchgate.net/publication/331201723_Engineering_the_microbiome_for_animal_health_and_conservation
4. "Advances in Microbiome Research for Animal Health" https://www.annualreviews.org/content/journals/10.1146/annurev-animal-091020-075907
5. Institutional Animal Care and committee Guideline (2002) 2nd Edition, Office of Laboratory Animal Welfare (OLAW) National Institutes of Health
6. CPCSEA Standard Operating Procedures (SOP) for IAEC (2010)
7. National Ethical Guidelines for Biomedical And Health Research Involving Human Participants (2017), Indian Council of Medical Research (ICMR)
8. HANDBOOK for INSTITUTIONAL BIOSAFETY COMMITTEES (IBSCs) (2020), Department of Biotechnology, Ministry of Science & Technology, Government of India, 3rd Edition

Unit-2 Plant Biotechnology in Agriculture Improvement

2.1 **Functional genomics in crop improvement**: CRISPR/Cas9 another genome editing tools (ZFNs, TALENs) in plants. Case studies: Use of CRISPR/Cas9 to develop disease-resistant rice or drought-tolerant maize. Tools used in functional genomics: microarrays, RNA-seq, TILLING, and gene knockout approaches. Gene expression profiling.

2.2 **Synthetic biology and artificial intelligence in crop improvement**: Machine learning and AI in plant phenotyping. Designing novel gene circuits, metabolic engineering, and synthetic pathways. Applications in creating biosensors, synthetic promoters, and novel traits (e.g., nitrogen fixation in cereals). Applications in high-throughput plant phenotyping: automated detection of stress, growth rate, and yield components. Use of 3D plant imaging and modelling: LiDAR, hyperspectral imaging, and deep learning in morphological analysis. Integration of omics data (genomics, proteomics, phenomics) using AI tools for predictive breeding.

2.3 **Biofortification:** Enhancing nutritional quality via genetic engineering, overexpression of transporter genes, pathway modification (e.g., carotenoid pathway in Golden Rice, Other examples of iron-rich beans, zinc-fortified wheat, role of cisgenic and transgenic techniques in biofortification.

2.4 **Micropropagation & Advanced Tissue Culture Technologies:** Hormone interaction-traditional auxins/cytokinins vs. novel regulators (meta-topolin, brassinosteroids, jasmonic/salicylic acid) and their effects on recalcitrant species and regeneration efficiency, Photoautotrophic tissue culture: sugar-free media, ventilated lids, CO_2 enrichment to reduce hyperhydricity, accelerate growth.

2.5 **Nanotechnology-Enhanced Culture Media**: Iron oxide nanoparticles (FeO-NPs), Fe_3O_4-NPs, metal NPs (Ag, Au, Zn, Ti, Si, Co, etc.) improves organogenesis, somatic embryogenesis, secondary metabolism, protoplast transformation, and cryopreservation. Bio-based nanoparticles

(cellulose, chitosan, lignin) enhance nutrient uptake, disease resistance-as elicitor, stress resilience, root development. Robotics & automation in media prep, explant handling, plantlet culture.

References:

1. Plant Biotechnology and Genetics by C. Neal Stewart Jr., Wiley-Blackwell, 2nd Ed., 2016, ISBN: 9781118889022.
2. Genome Editing in Plants by Om Prakash Dhankher, Springer, 1st Ed., 2021, ISBN: 9783030601571.
3. Synthetic Biology in Agriculture and Food Production by Pallaval Veera Bramhachari.
4. Nameirakpam, R., Singh, J., Singh, P., & Hedabou, M. (2024). A review of artificial intelligence-based plant species classification techniques. Advances in Networks, Intelligence and Computing, 259-268.
5. Kumar, S., Dikshit, H. K., Mishra, G. P., Singh, A., Aski, M., & Virk, P. S. (2022). Biofortification of staple crops: present status and future strategies. In *Biofortification of Staple Crops* (pp. 1-30). Singapore: Springer Singapore.
6. Plant Tissue Culture: Theory and Practice by S.S. Bhojwani and M.K. Razdan.
7. Nanotechnology and Plant Sciences by Manzer H. Siddiqui.

Unit 3: Bioprocess and Translational Microbiology

3.1 Bioprocess Technology: Isolation, screening and strain improvement of microorganisms. Polyphasic concept in Microbial identification. Fermentation-Solid state and Submerged, Fermenter: Components and types, upstream and downstream processing, Immobilized cell system- Active and passive immobilization, Bioreactors for immobilized cell culture, Biofilms reactors.

3.2 Drug discovery and development: Process and key stages

3.3 Advanced Diagnostics methods: Genotyping and molecular marker in Diagnostic bacteriology- Molecular marker, Nucleic acid-based typing, biotyping, optical map typing, Pulsotyping, Sequence typing.

3.4 Bacterial Genome Project: NGS technologies, Genome Sequencing Strategies, Gene annotation, WGS, 100K & 100,000 genome project, Human Microbiome Project, Plasmid sequencing project, RNA Genome project. MDR Bacteria Genome Editing: Conventional Genome Editing, Editing by Targetron and recombinases and by Engineered Nucleases, ZFN and TALEN. Genome Editing in MDR bacterial species: CRISPR and Modified CRISPR, Identification of Cas9and Application of genome editing.

3.5 Microbiology at Field: Various Phases of Wastewater Technologies and trends and future perspectives, Solid waste and their sustainable management practices, Bioremediation and biodegradation technologies for removal of pollutants and wastes, Bioleaching- recovery of metals, MICP- Microbiological and Molecular Concepts

References:

1. P F Stanbury, A Whitaker & S. J. Hall, 2017. Principles of Fermentation Technology, 3rd Ed. ISBN: 978-0080999531
2. BERGEY'S MANUALOF Systematic Bacteriology Second Edition, Volume One, 2001, Springer ISBN 978-1-4419-3159-7
3. Sibi G. 2019. Industrial Microbiology and Biotechnology, ISBN: 978-93-5299-150-1
4. Kristian Strømgaard, Povl Krogsgaard-Larsen, Ulf Madsen, 2017, Textbook of Drug Design and Discovery, Fifth Edition, CRC press, ISBN: 978-1-4987-0278-2Smarnika Pattnaik, 2021. Diagnostic Bacterial Genomics, ISBN: 9789352735471
5. Fernandes, J., Ramísio, P. J., & Puga, H. (2024). A Comprehensive Review on Various Phases of Wastewater Technologies: Trends and Future Perspectives. Eng, 5(4), 2633-2661.

6. Ashok K Rathoure, Shashwat Katiyar, Harish Chandra and Rupesh Kumar Luhariya, 2021. SUSTAINABLE PRACTICES FOR WASTE MANAGEMENT, ISBN-9789388854665
7. Ronald M. Atlas, Richard Bartha, 1997, 4th edition Microbial Ecology: Fundamentals and Applications, ISBN: 978-0805306552
8. Castro-Alonso, M. J., Montañez-Hernandez, L. E., Sanchez-Muñoz, M. A., Macias Franco, M. R., Narayanasamy, R., & Balagurusamy, N. (2019). Microbially induced calcium carbonate precipitation (MICP) and its potential in bioconcrete: microbiological and molecular concepts. Frontiers in Materials, 6, 126.

Unit 4: Review or Case Study Preparation

This unit is designed to develop the ability of PhD scholars to critically analyze scientific literature and prepare scholarly Review or Case Study aligned with their research domain. The process will encourage independent learning under faculty/ Guide supervision and prepare candidates for high-quality scientific writing and publication.

Course Content & Guidelines

1. **Selection of Literature (Syllabus Definition):**
   - Each PhD guide will select at least five (5) review articles from Clarivate (Web of Science) or Scopus-indexed reputed journals, related to the candidate's research topic. These five articles will constitute the syllabus for this unit, and scholars are expected to study them thoroughly.
2. **Critical Appraisal:**
   - Candidates will analyze the selected articles in terms of research trends and methodologies, identification of knowledge gaps and relevance to their doctoral work.
3. **Review Preparation:**
   - Each scholar will prepare a comprehensive review article on their PhD topic under the guidance of their respective supervisor by following ethical writing standards and referencing guidelines.
4. **Assessment Components:**
   - Theory Examination (50%): Based on the five selected review articles.
   - Assignment (50%): Preparation and submission of a review article as an internal assignment.

Reference:

1. Bahl, M. (2023). A Step-by-Step Guide to Writing a Scientific Review Article. *Journal of Breast Imaging*, *5*(4), 480-485.
2. Dhillon, P. (2022). How to write a good scientific review article. *The FEBS Journal*, *289*(13), 3592-3602.
3. Chatterjee, K., Davies, G. L., Engqvist, H., & Winter, J. (2025). Writing an impactful Review: top tips from the Editors. *Journal of Materials Chemistry B*, *13*(13), 4041-4044.