

**BHAKTA KAVI NARSINH MEHTA UNIVERSITY,
JUNAGADH**



BOARD OF STUDIES (MICROBIOLOGY)

FACULTY OF LIFE SCIENCES

SYLLABUS FOR

MASTER OF SCIENCE PROGRAMME

(COURSEWORK WITH RESEARCH)

SUBJECT: MICROBIOLOGY

(SEMESTER- I & II)

EFFECTIVE FROM JUNE, 2026

PREFACE

The postgraduate curriculum plays a pivotal role in advancing disciplinary knowledge, developing research aptitude, and preparing students for professional careers in academia, industry, and scientific research. In the rapidly evolving field of biological sciences, continuous revision and upgradation of the curriculum are essential to incorporate emerging concepts, modern technologies, interdisciplinary approaches, and contemporary research trends at national and global levels.

The National Education Policy (NEP) 2020 envisions postgraduate education as a platform for promoting critical thinking, creativity, innovation, scientific inquiry, and multidisciplinary learning. The policy emphasizes research-oriented education, experiential learning, skill development, and integration of modern tools and technologies to address complex biological and environmental challenges.

Keeping these objectives in view, the Board of Studies in Microbiology has designed the syllabus for the Master of Science Programme in Microbiology (Coursework with Research) in accordance with the guidelines of UGC and NEP-2020. The curriculum has been developed through extensive deliberations and academic discussions among subject experts, teachers, and researchers to ensure relevance, academic rigor, and alignment with current developments in biological sciences.

The Semester I and II curriculum provides a strong foundation in Biochemistry, Molecular Biology, Biotechnology, Immunology, Biostatistics, Research Methodology, Intellectual Property Rights, Analytical Techniques, Marine Biology, Forestry, Bioinformatics, Bioethics, Biosafety, Good Laboratory Practices, and Artificial Intelligence in Biological Sciences. The programme integrates theoretical knowledge with practical training, field-based learning, computational approaches, scientific communication, and research-oriented skill development. The curriculum aims to equip students with advanced knowledge, analytical abilities, technical competencies, ethical values, and research skills required for higher studies, doctoral research, entrepreneurship, and employment opportunities in academic institutions, research

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organizations, biotechnology industries, environmental agencies, healthcare sectors, and allied life science disciplines.

We sincerely hope that this curriculum will foster scientific temperament, innovation, and lifelong learning while preparing students to contribute meaningfully to the advancement of biological sciences and sustainable development.

Board of Studies in Microbiology

Faculty of Life Sciences

Bhakta Kavi Narsinh Mehta University

Junagadh – 362001

BHAKTA KAVI NARSINH MEHTA UNIVERSITY**Syllabus of M.Sc. (2 years) as per NEP-2020****Faculty of Life Sciences****Effective from June 2026****Subject: Microbiology****SEMESTER- I & II****SUMMARY OF THE SYLLABUS FOR A TWO-YEAR POST-GRADUATION PROGRAMME****(COURSEWORK WITH RESEARCH)****PG 1st Year****Semester-I**

Sr. No.	Level	SEM	Course Group	Course (Paper) Title	Paper No.	Credit	Teaching Hours/ Week	Internal Marks	External Marks	Practical Internal Marks	Practical External Marks	Total Marks/ Passing
								Total/ Passing	Total /Passing	Total/ Passing	Total/ Passing	
1	PG	1	DSC	Biochemistry and Molecular Biology	DSC-101	4	4	30/12	70/28	--	-	100/40
2	PG	1	DSC	Biotechnology and Immunology	DSC-102	4	4	30/12	70/28	-	-	100/40
3	PG	1	DSC	Biostatistics, Research Methodology and IPR	DSC-103	4	4	30/12	70/28	-	-	100/40
4	PG	1	DSC	Combined Practical-I (Biochemistry, Biotechnology, Research Methodology & IPR)	DSC-104	4	8	-	-	30/12	70/28	100/40
5	PG	1	DSC	Combined Practical-II (Molecular Biology, Immunology & Biostatistics)	DSC-105	4	8	-	-	30/12	70/28	100/40
6	PG	1	SEC	Good Laboratory Practices & Biosafety	SEC-101	2	4	-	-	15/06	35/14	50/20
Total						22	32					550

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Course Level	6.0	Internal Marks	30
Programme	M.Sc. Microbiology	External Marks	70
Semester	I	Practical Internal	--
Category of Course	Discipline Specific Course-101	Practical External	--
Course Credit	04	Prac. External Exam Duration	--
Teaching Hours	60	Total	100
Course Code		Exam Duration	2.30 Hrs.
Course Title	Biochemistry and Molecular Biology		

Course Objectives:

1. To develop an understanding of biochemical processes governing cellular metabolism, enzyme action, and energy transformation in living systems.
2. To explain the molecular organization of genes and genomes and analyze mechanisms regulating gene expression in prokaryotes and eukaryotes.
3. To evaluate mutations, chromosomal alterations, DNA repair mechanisms, and their significance in heredity, evolution, and biotechnology.

Course Learning Outcomes: After completion of the course, students will be able:

1. Analyze metabolic pathways, enzyme kinetics, and biochemical mechanisms underlying cellular functions.
2. Interpret gene organization and explain molecular mechanisms of transcription, translation, and gene regulation.
3. Evaluate the effects of mutations and chromosomal abnormalities and assess DNA repair systems in maintaining genome integrity.
4. Apply molecular biology concepts in biotechnology, plant breeding, and genetic improvement programmes.

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DSC-101 Biochemistry and Molecular Biology

Sem.	Unit No.	Syllabi	Teaching Hours
1	1	Advanced Metabolic Biochemistry 1.1 Macronutrients and micronutrients: vitamins and major minerals; their roles in enzyme function, nerve conduction, and oxygen transport. 1.2 Photosynthesis: light reactions, photophosphorylation, electron transport, and Calvin cycle. 1.3 Biosynthesis and functions of plant secondary metabolites: alkaloids, flavonoids, terpenoids; ecological and medicinal roles. 1.4 Bioenergetics: ΔG , ATP as energy currency, high-energy phosphate compounds (e.g., phosphoenolpyruvate, 1,3-bisphosphoglycerate, creatine phosphate).	15
	2	Enzymes and Enzyme Kinetics 2.1 Enzyme nomenclature, active site, cofactors, coenzymes, and isoenzymes. 2.2 Michaelis–Menten kinetics, Lineweaver–Burk plots, and kinetic parameters (K_m , V_{max}); inhibition types: competitive, non-competitive, uncompetitive, and mixed inhibition. 2.3 Allosteric regulation, feedback inhibition, and cooperativity (e.g., haemoglobin and aspartate transcarboxylase). 2.4 Microbial enzyme production and industrial applications: amylases, proteases, lipases, cellulases, and pectinases. 2.5 Recombinant microbial systems for production of human proteins (e.g., insulin, growth hormone) using bacteria and yeast.	15
	3	Gene Structure and Expression 3.1 Concept of Gene: classical to molecular definition, fine structure of gene (cistron–recon–muton), gene organization, split genes, gene families, pseudogenes, overlapping genes, and transposable elements. 3.2 Gene expression I: genetic code and its properties, transcription in prokaryotes and eukaryotes, RNA polymerases, transcription factors, and RNA processing (capping, splicing, polyadenylation, RNA editing and transport). 3.3 Gene expression II: translation in prokaryotes and eukaryotes, ribosome structure and function, genetic code	15

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		interpretation, translational regulation, protein folding, targeting, and post-translational modifications. 3.4 Regulation of gene expression: operon models in prokaryotes, transcriptional regulation in prokaryotes and eukaryotes, epigenetic regulation, RNA-mediated regulation, chromatin remodeling, and gene regulatory networks.	
	4	Mutation, Chromosomal Variation, DNA Repair, and Cytoplasmic Inheritance 4.1 Molecular basis of mutations: spontaneous and induced mutations, types of gene mutations, mutagenic agents, mechanisms of mutagenesis, and effects on gene function. 4.2 Structural and numerical chromosomal aberrations: mechanisms, causes, and genetic consequences. 4.3 DNA damage: sources, types, and molecular mechanisms of DNA repair systems in prokaryotes and eukaryotes. 4.4 Cytoplasmic inheritance: mitochondrial and chloroplast genomes, maternal inheritance, and non-Mendelian inheritance patterns.	15

Suggested Reading:

- Lehninger Principles of Biochemistry by David L. Nelson & Michael M. Cox
- Harper's Illustrated Biochemistry by Victor W. Rodwell, David A. Bender, Kathleen M. Botham, Peter J. Kennelly & P. Anthony Weil
- Introduction to Plant Biochemistry by Trevor Palmer
- Enzymes: Biochemistry, Biotechnology, Clinical Chemistry by Palmer & Bonner
- Industrial Microbiology by L. E. Casida Jr.
- Genes XII by Benjamin Lewin
- Biochemistry by U. Satyanarayana & U. Chakrapani
- Cell and Molecular Biology by P. K. Gupta
- Molecular Biology by Veer Bala Rastogi.
- The physiology and Biochemistry of Prokaryotes, 2nd edition By. David white
- Outlines of biochemistry By- Conn E.E. and Stumpt P.K.: 4th Ed
- General microbiology by Stanier R.Y.: 5th Ed.
- General microbiology by Powar and Daginawala Vol-1
- Molecular Biology of the Gene
- Molecular Biology of the Cell
- Molecular Cell Biology

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Course Level	6.0	Internal Marks	30
Programme	M. Sc. Microbiology	External Marks	70
Semester	I	Practical Internal	--
Category of Course	Discipline Specific Course-102	Practical External	--
Course Credit	04	Prac. External Exam Duration	--
Teaching Hours	60	Total	100
Course Code		Exam Duration	2.30 Hrs
Course Title	Biotechnology and Immunology		

Course Objectives:

1. To introduce the principles and applications of plant biotechnology, recombinant DNA technology, and genetic manipulation in agriculture, industry, and environmental management.
2. To develop an understanding of plant and animal tissue culture techniques and their applications in crop improvement and biotechnology research.
3. To explain the fundamental concepts of immunology and immunological techniques used in biological research and diagnostics.
4. To examine plant defense mechanisms, plant immune responses, and plant-microbe interactions and evaluate their applications in disease management and sustainable agriculture.

Course Learning Outcomes: After completion of the course, students will be able:

1. Apply recombinant DNA technology, gene transfer methods, and tissue culture techniques in plant biotechnology and crop improvement.
2. Analyze antigen-antibody interactions and interpret immunological techniques used in biological research and diagnostics.
3. Explain plant defense mechanisms and plant immune responses, including PTI, ETI, SAR, and ISR, in plant-pathogen interactions.
4. Evaluate the role of plant biotechnology, disease resistance breeding, biological control agents, PGPR, and sustainable disease management strategies in modern agriculture.

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DSC-102 Biotechnology and Immunology

Sem.	Unit No.	Syllabi	Teaching Hours
1	1	Basics of Biotechnology and Recombinant Technology 1.1 Biotechnology: definition, scope, historical development, and applications; enzyme and cell immobilization techniques and their industrial applications. 1.2 Principles of bioremediation, fundamentals of genetic engineering, and techniques for nucleic acid isolation and purification. 1.3 Restriction endonucleases, molecular scissors in DNA manipulation, and gene targeting strategies for genome modification. 1.4 Molecular cloning vectors: plasmids (pBR322, pUC series), bacteriophages (λ phage), cosmids, and host-vector systems for gene cloning and expression (YACs).	15
	2	Animal and Plant Tissue Culture 2.1 Fundamental principles of plant tissue culture, aseptic techniques, and culture environment optimization. 2.2 Types of Plant Tissue Culture: Callus culture, Cell suspension, Meristem, Shoot tip, Anther/pollen, Embryo culture, Protoplast culture and fusion. 2.3 Basic Steps of Plant Tissue Culture 2.4 Animal cell culture principles, techniques (Aseptic handling techniques, Cell counting, Cell viability test, Sub-culturing, Cryopreservation of animal cells) and applications in biotechnology	15
	3	Immunology-I 3.1 Antigen Antibody: Factors Influencing Immunogenicity, Structure of Ig, Ig Classes & Biological Activities, Monoclonal antibodies and polyclonal antibodies 3.2 Innate and Adaptive Immune System 3.3 Antigen-Antibody Interactions: ELISA Test, Agglutination, Precipitation, Immunofluorescence, Radioimmunoassay	15
	4	Immunology-II 4.1 Immunodeficiency diseases 4.2 Hypersensitivity 4.3 Autoimmune diseases 4.4 Autoinflammatory disorders	15

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Suggested Reading:

1. Immunology – 5th edition – J. Kuby, R. A. Goldsby, T.J.Kindt B.A. Osborne – W.H. Freeman and Company , New York
2. Principles of Microbiology- 2nd edition – R.M.Atlas – Wm.C.Brown Publishers
3. Microbiology – 5th edition – Prescott, Harley, Klein – McGrawHill Publishers
4. Instant Notes in Microbiology – P.M. Lyolyard, A. Whelan, M.W. Fanger
5. Immunology – Raj Khanna – Oxford University Press

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Course Level	6.0	Internal Marks	30
Programme	M.Sc. Microbiology	External Marks	70
Semester	I	Practical Internal	-
Category of Course	Discipline Specific Elective Course-103	Practical External	--
Course Credit	04	Prac. External Exam Duration	--
Teaching Hours	60	Total	100
Course Code		Exam Duration	2.30 Hrs.
Course Title	Biostatistics, Research Methodology and IPR		

Course Objectives:

1. To introduce statistical concepts and analytical tools used in biological research.
2. To develop skills in research design, data collection, hypothesis formulation, and scientific writing.
3. To familiarize students with emerging applications of Artificial Intelligence and Machine Learning in biological sciences.
4. To enable students to interpret biological data and apply statistical and computational tools in research.

Course Learning Outcomes: After completion of the course:

1. Apply statistical methods for analysis and interpretation of biological data.
2. Design scientific research projects using appropriate methodologies and ethical practices.
3. Use statistical software and AI-based tools for data analysis and problem-solving.
4. Evaluate biological datasets and scientific literature using quantitative approaches.
5. Explain the applications of Artificial Intelligence and Machine Learning in agriculture, plant sciences, biodiversity studies, and environmental monitoring.

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DSC-101 Biostatistics, Research Methodology and IPR

Sem.	Unit No.	Syllabi	Teaching Hours
1	1	Basics and Concepts of Biostatistics 1.1 Data classification, Frequency distribution and Graphs. 1.2 Measure of Central Tendency: Meaning, Objectives, Merits, Demerits & Uses. 1.3 Measure of Dispersion – Range, Variance, Standard deviation, Coefficient of Variation; Confidence limit and confidence interval. 1.4 Probability distributions (Binomial, Poisson and normal), Sampling distribution; Difference between parametric and non-parametric statistics; Confidence Interval; Errors; Levels of significance.	15
	2	Statistical tests in Biology 2.1 Regression and Correlation Analysis. 2.2 Student's t-test: Paired and Unpaired. 2.3 Level of Significance & Degree of Freedom: Chi-square test (X ²); Analysis of Variance (ANOVA) 2.4 Basics of Multivariate statistics.	15
	3	Basic Research Methodology 3.1 Research problem, Aims & Objectives, types of scientific research 3.2 Hypothesis formulation and testing; Literature survey, literature review and scientific writing. 3.3 Sampling techniques, optimization of protocol, graphical data analysis, data validation 3.4 Plagiarism, Referencing tools	15
	4	Intellectual Property Rights (IPR) 4.1 Fundamentals of IPR: Patents, Trademarks, Copyrights, Geographical Indications, Traditional Knowledge and Protection of GMOs 4.2 International IPR Framework: IPR in Research and Development; GATT, WTO, WIPO and TRIPS; Case studies: Turmeric, Neem and Basmati Rice 4.3 Patents in Biotechnology: Gene, Microorganism and Process Patents; Budapest Treaty and International Depository Authorities; Patent application procedures: Provisional, Complete and PCT applications 4.4 IPR, Commercialization and Legal Issues: Licensing, Technology Transfer and Start-ups; Indian Patent Act, 1970	15

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		and Biological Diversity Act, 2002; Emerging trends: CRISPR and Gene Editing Patents.	
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Suggested Readings

1. Introduction to Bio-Statistics, Banerjee Pranab Kumar, S Chand & Company
2. Biostatistics, Veer Bala Rastogi, Medtech
3. Biostatistics Analysis, Zar, Pearson
4. Biostatistics for health and life sciences, Rao K Surya, Himalaya Publishing house
5. An Introduction to Biostatistics, Gurumani
6. Research methodology, C R Kothari, New Age Publishers
7. Principles of Biostatistics by Marcello Pagano, Duxbury Thomson Learning
8. IPR, Biosafety and Bioethics, Goel and Parashar, Person
9. A Book on Indian Patenting System and Patent Agent Examination, Sheetal Chopra, Notion Press
10. Press
11. Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers, Anil Kumar, Ramakrishna, Notion Press
12. Intellectual Property Rights (IPRs): TRIPS Agreement & Indian Laws, E. T. Lokganathan, New Century Publications
13. How to Patent an Idea in India, Prasad Karhad
14. Building Biotechnology: Biotechnology Business, Regulations, Patents, Law, Policy and
15. Science Paperback, Yali Friedman, Logos PressPR, Biosafety and Bioethics, Goel and Parashar, Person
16. Intellectual Property Rights in Agricultural Biotechnology by F.H. Erbisch
17. Intellectual Property Rights by Neeraj Pandey
18. WIPO Intellectual Property Handbook, World Intellectual Property Organization

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Programme	Microbiology		External Marks	-
Semester	I		Practical Internal	30
Category of Course	Discipline Specific Course-104		Practical External	70
Course Credit	04		Prac. External Exam Duration	4 Hrs.
Teaching Hours	120		Total	100
Course Code			Exam Duration	-
Course Title	Combined Practical-I (Biochemistry, Biotechnology, Research Methodology & IPR)			

Course Objectives:

1. To develop laboratory skills in biochemical analysis, enzyme assays and basic biotechnology techniques.
2. To provide hands-on training in plant tissue culture, DNA analysis, data interpretation and modern biological research methods.
3. To familiarize students with scientific writing, literature review, plagiarism assessment, intellectual property protection and patent documentation.

Course Learning Outcomes: After completion of the course, students will be able to:

1. Perform biochemical estimations, enzyme assays and basic biotechnology experiments using standard laboratory procedures.
2. Demonstrate skills in plant tissue culture, DNA analysis and interpretation of experimental results.
3. Formulate research problems, conduct literature surveys, manage references and prepare scientific reports and research proposals.
4. Apply ethical research practices, plagiarism assessment tools and scientific documentation techniques.
5. Explain basic concepts of Intellectual Property Rights, patenting procedures and technology commercialization in biological sciences.

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Suggested Practical Course Contents

DSC-104 Combined Practical-I

Sr. No.	Practical Exercise	Teaching Hours
1	Qualitative analysis of carbohydrates, proteins and lipids.	120
2	Estimation of reducing sugars by DNSA method.	
3	Estimation of proteins by Folin-Lowry method.	
4	Determination of enzyme activity (Amylase/Catalase).	
5	Determination of enzyme kinetics (Km and Vmax) using Lineweaver-Burk plot.	
6	Qualitative analysis of plant secondary metabolites (alkaloids, flavonoids, tannins, saponins, terpenoids).	
7	Preparation and sterilization of culture media and laboratory glassware.	
8	Preparation of Murashige and Skoog (MS) medium.	
9	Surface sterilization and inoculation of plant explants.	
10	Demonstration of callus induction and micropropagation techniques.	
11	Isolation and estimation of DNA by spectrophotometric methods.	
12	Agarose gel electrophoresis of DNA samples (demonstration).	
13	Restriction digestion and interpretation of DNA banding patterns (demonstration).	
14	Preparation of a research problem, aims, objectives and hypothesis for a selected topic.	
15	Literature survey using Google Scholar, Scopus and Web of Science databases.	
16	Preparation of a review article and scientific report.	
17	Reference management using Mendeley/Zotero software.	
18	Plagiarism checking and interpretation of plagiarism reports.	
19	Study of patent documents and patent databases (Indian Patent Office, WIPO, Google Patents).	
20	Preparation of a mock patent draft for a biological innovation/product.	
21	Case studies on Turmeric, Neem and Basmati patents.	
22	Seminar presentation on Biotechnology, Research Methodology or IPR-related topics.	
23	Mini Project: Experimental work/data collection, analysis and presentation of results.	
24	Visit to Biotechnology Laboratory / Research Institute / Patent Facilitation Centre and submission of report.	

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Suggested Reading:

1. Jayaraman, J. Laboratory Manual in Biochemistry. New Age International Publishers, New Delhi.
2. Wilson, K. & Walker, J. Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.
3. Bhojwani, S.S. & Razdan, M.K. Plant Tissue Culture: Theory and Practice. Elsevier Science Publishers.
4. Chawla, H.S. Introduction to Plant Biotechnology. CRC Press/Taylor & Francis.
5. Kothari, C.R. & Garg, G. Research Methodology: Methods and Techniques. New Age International Publishers.
6. Kumar, R. Research Methodology: A Step-by-Step Guide for Beginners. Sage Publications India.
7. Nithyananda, K.V. Intellectual Property Rights: Protection and Management. Cengage Learning India.
8. Ganguli, P. Intellectual Property Rights: Unleashing the Knowledge Economy. Tata McGraw-Hill.
9. WIPO. WIPO Intellectual Property Handbook: Policy, Law and Use. World Intellectual Property Organization.

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Programme	M.Sc. Microbiology	External Marks	-
Semester	I	Practical Internal	30
Category of Course	Discipline Specific Elective Course-105	Practical External	70
Course Credit	04	Prac. External Exam Duration	4 Hrs.
Teaching Hours	120	Total	100
Course Code		Exam Duration	-
Course Title	Combined Practical-II (Molecular Biology, Immunology & Biostatistics)		

Course Objectives:

1. To provide hands-on training in molecular biology techniques including nucleic acid isolation, quantification, electrophoresis and molecular data analysis.
2. To develop practical skills in immunological techniques used for antigen-antibody detection and disease diagnosis.
3. To train students in statistical methods, data analysis and interpretation of biological datasets using appropriate software tools.
4. To enhance scientific reasoning, data presentation and interpretation skills for biological research.

Course Learning Outcomes: After completion of the course, students will be able to:

1. Isolate, quantify and analyze nucleic acids using standard molecular biology techniques.
2. Perform immunological assays and interpret antigen-antibody interactions.
3. Apply statistical methods for analysis of biological data and draw meaningful conclusions.
4. Use software tools for graphical representation, statistical testing and data interpretation.
5. Integrate molecular, immunological and statistical approaches in biological research.

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Suggested Practical Course Contents

DSC-105 Combined Practical-I

Sr. No.	Practical Exercise	Teaching Hours
1	Isolation and quantitative estimation of DNA from plant tissues.	120
2	Quantitative estimation of RNA by Orcinol method.	
3	Determination of DNA purity and concentration using spectrophotometry.	
4	Agarose gel electrophoresis of DNA samples and interpretation of banding patterns.	
5	Demonstration of restriction digestion and PCR techniques.	
6	Study of gene cloning vectors and retrieval of nucleotide sequences from NCBI database.	
7	Dot ELISA and Direct/Indirect ELISA techniques.	
8	Ouchterlony Double Diffusion and Radial Immunodiffusion techniques.	
9	Agglutination reaction and blood grouping.	
10	Preparation of frequency distribution tables and graphical presentation of biological data.	
11	Calculation of Mean, Median, Mode, Standard Deviation and Coefficient of Variation.	
12	Correlation and Regression analysis using biological datasets.	
13	Student's t-test, Chi-square test and Analysis of Variance (ANOVA).	
14	Statistical analysis and graphical presentation of biological data using MS Excel/SPSS/R software.	
15	Mini-project involving collection, analysis and interpretation of biological data and submission of a report.	

Suggested Reading:

1. Wilson, K. & Walker, J. Principles and Techniques of Biochemistry and Molecular Biology.
2. Sambrook, J. & Russell, D.W. Molecular Cloning: A Laboratory Manual.
3. Green, M.R. & Sambrook, J. Molecular Cloning: Laboratory Manual.
4. Brown, T.A. Gene Cloning and DNA Analysis: An Introduction.
5. Glick, B.R. & Pasternak, J.J. Molecular Biotechnology.
6. Kubly, J. Immunology.
7. Goldsby, Kindt & Osborne. Kubly Immunology.
8. Roitt, I.M. Essential Immunology.
9. Delves, Martin & Burton. Roitt's Essential Immunology.
10. Raj Khanna. Immunology.

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11. Banerjee, P.K. Introduction to Biostatistics.
12. Rastogi, V.B. Biostatistics.
13. Zar, J.H. Biostatistical Analysis.
14. Pagano, M. & Gauvreau, K. Principles of Biostatistics.
15. Daniel, W.W. Biostatistics: A Foundation for Analysis in the Health Sciences.

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Course Level	6.0	Internal Marks	-
Programme	M.Sc. Microbiology	External Marks	-
Semester	I	Practical Internal	15
Category of Course	Skill Enhancement Course-101	Practical External	35
Course Credit	02	Prac. External Exam Duration	2 Hrs.
Teaching Hours	60	Total	50
Course Code		Exam Duration	
Course Title	Good Laboratory Practice and Biosafety		

Course Objectives: By completing the course, this course aims to:

1. Understand and implement the principles of Good Laboratory Practices (GLP), laboratory organization, documentation, and quality management systems.
2. Develop practical skills in the operation, calibration, maintenance, and quality control of laboratory instruments and equipment.
3. Apply laboratory safety measures, risk assessment procedures, biosafety guidelines, and ethical practices for safe and reliable scientific investigations.

Course Learning Outcomes: After completion of the course, students will be able:

1. Prepare and maintain laboratory records, SOPs, logbooks, inventory registers, and other GLP-compliant documentation.
2. Perform calibration, quality control, and routine maintenance of laboratory instruments while ensuring accuracy and reliability of experimental data.
3. Demonstrate laboratory safety, risk assessment, waste management, and GLP compliance practices in academic and research laboratories.

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Practical Course Contents

SEC-101

Sr. No.	Practical	Teaching Hours
1	Laboratory orientation and identification of Good Laboratory Practice (GLP) requirements in a biological laboratory.	60
2	Preparation of Standard Operating Procedure (SOP) for a laboratory experiment (e.g., media preparation, pH measurement, herbarium preparation).	
3	Preparation and maintenance of laboratory notebook, equipment logbook, stock register, and reagent register.	
4	Preparation of labels, coding system, sample accession records, and sample tracking forms.	
5	Calibration and operation of pH meter; preparation of calibration records.	
6	Calibration and operation of analytical balance and maintenance of calibration logbook.	
7	Calibration and correct use of micropipettes; determination of pipetting accuracy and precision.	
8	Operation, cleaning, and maintenance records of spectrophotometer/UV-Vis spectrophotometer.	
9	Preparation of inventory records for chemicals, glassware, and laboratory consumables.	
10	Quality Control (QC) exercise: preparation of standard solutions and validation of measurements.	
11	Laboratory risk assessment: identification of chemical, biological, and physical hazards and preparation of risk assessment forms.	
12	Demonstration and use of Personal Protective Equipment (PPE), emergency response procedures, and safety signage.	
13	Segregation, collection, treatment, and disposal of chemical, biological, and glass waste according to biosafety guidelines.	
14	Laboratory safety audit and GLP compliance assessment using a standard checklist.	
15	Preparation of a GLP audit report including observations, non-conformities, corrective actions, and recommendations.	
16	Preparation and interpretation of Material Safety Data Sheets (MSDS) for commonly used laboratory chemicals.	
17	Environmental monitoring of laboratory conditions (temperature, humidity, illumination, cleanliness records).	
18	Validation and verification of laboratory instruments and experimental procedures.	
19	Data integrity and electronic record management practices.	

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Sr. No.	Practical	Teaching Hours
20	Mini-project: Comprehensive GLP assessment of a teaching/research laboratory and submission of a compliance report.	

Suggested Readings

1. WHO. *Handbook: Good Laboratory Practice (GLP)*.
2. WHO. *Laboratory Quality Management System (LQMS)*.
3. OECD. *OECD Principles of Good Laboratory Practice*.
4. Sateesh, M.K. *Bioethics and Biosafety*.
5. Wilson, K. & Walker, J. *Principles and Techniques of Biochemistry and Molecular Biology*.
6. Department of Biotechnology (DBT), Government of India. *Biosafety Guidelines and Biosafety Manual*.

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SUMMARY OF THE SYLLABUS FOR A TWO-YEAR POST-GRADUATION PROGRAMME

(COURSEWORK WITH RESEARCH)

Semester-II

Sr. No.	Level	SEM	Course Group	Course (Paper) Title	Paper No.	Credit	Teaching Hours/ Week	Internal Marks	External Marks	Practical Internal Marks	Practical External Marks	Total Marks/ Passing
								Total/ Passing	Total /Passing	Total/ Passing	Total/ Passing	
1	PG	2	DSC	Analytical Techniques	DSC-201	4	4	30/12	70/28	--	-	100/40
2	PG	2	DSC	Marine Biology and Forestry	DSC-202	4	4	30/12	70/28	-	-	100/40
3	PG	2	DSC	Bioinformatics and Bioethics	DSC-203	4	4	30/12	70/28	-	-	100/40
4	PG	2	DSC	Combined Practical-I (Analytical Techniques & Bioinformatics)	DSC-204	4	4	-	-	30/12	70/28	100/40
5	PG	2	DSC	Combined Practical-II (Marine Biology, Forestry & Bioethics)	DSC-205	4	12	-	-	30/12	70/28	100/40
6	PG	2	SEC	Artificial Intelligence in Biological Sciences	SEC-201	2	4	-	-	15/06	35/14	50/20
Total						22	32					550

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Course Level	6.0	Internal Marks	30
Programme	M.Sc. Microbiology	External Marks	70
Semester	II	Practical Internal	-
Category of Course	Discipline Specific Course-201	Practical External	-
Course Credit	04	Prac. External Exam Duration	-
Teaching Hours	60	Total	100
Course Code		Exam Duration	2.30 Hrs.
Course Title	Analytical Techniques (Theory)		

Course Objectives:

1. Understand the principles, fundamentals, and applications of microscopy and autoradiography.
2. Describe the principles and instrumentation of spectroscopic techniques.
3. Apply chromatographic and electrophoresis methods for the separation and analysis of biomolecules.

Course Learning Outcomes: After completion of the course:

1. Explain and understand the principles of microscopy and autoradiographic techniques.
2. Understand and interpret spectroscopy for biomolecular analysis.
3. Apply chromatographic and electrophoresis methods for separation and quantification.

Course Contents

DSC-201 Analytical Techniques

Sem	Unit No.	Syllabi	Teaching Hours
2	1	Microscopy and Autoradiography 1.1 Theories of Tissue fixation and staining techniques. 1.2 Principles of Transmission and Scanning Electron Microscopy. 1.3 Principles of Phase Contrast and Fluorescence Microscopy. 1.4 Principles and applications of Autoradiography.	15
	2	Spectroscopy 2.1 Basic principles of Spectroscopy, UV, IR, Raman, ESR, ORD. 2.2 CD and structure of proteins using NMR.	15

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		2.3 Neutron and X-Ray diffraction for elucidation of 3D structure. 2.4 Molecular modelling, Mass Spectrometry	
	3	Chromatographic techniques 3.1 Basic Principles and Types of Chromatography. 3.2 Gas Chromatography & GC-MS, MALDI-TOF, LC-MS/MS. 3.3 Ion Exchange Chromatography, gel permeation, Affinity chromatography. 3.4 High Performance Liquid Chromatography and FPLC.	15
	4	Centrifugation and Electrophoretic Techniques 4.1 Principles and applications of Centrifugation techniques. 4.2 Basic principles of Electrophoresis, Agarose gel, native and SDS-PAGE. 4.3 Isoelectric focusing, 2D-PAGE and their uses in protein research. 4.4 Fractionation and Blotting Technique.	15

Suggested Reading:

1. Principles and Techniques of Biochemistry and Molecular Biology by Keith Wilson & John Walker.
2. Introduction to Spectroscopy by Donald L. Pavia
3. Chromatography: Concepts and Contrasts by James M. Miller

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Course Level	6.0	Internal Marks	30
Programme	M.Sc. Microbiology	External Marks	70
Semester	II	Practical Internal	-
Category of Course	Discipline Specific Course-202	Practical External	-
Course Credit	04	Prac. External Exam Duration	-
Teaching Hours	60	Total	100
Course Code		Exam Duration	2.30 Hrs.
Course Title	Marine Biology and Forestry (Theory)		

Course Objectives:

1. To understand the structure, diversity and ecological significance of marine and forest ecosystems.
2. To develop knowledge of marine and forest biodiversity, ecosystem functioning and resource utilization.
3. To evaluate conservation strategies, sustainable management practices and emerging biotechnological applications in marine and forest environments.

Course Learning Outcomes: After completion of the course, students will be able to:

1. Explain the physical, chemical and biological characteristics of marine and forest ecosystems.
2. Analyze the diversity and ecological roles of marine organisms, microorganisms and forest biota.
3. Assess marine and forest resources, biodiversity conservation measures and environmental challenges.
4. Apply concepts of sustainable management, biotechnology and climate change mitigation in marine and forest ecosystems.

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Course Contents

DSC-202 Marine Biology and Forestry

Sem	Unit No.	Syllabi	Teaching Hours
2	1	Marine Ecosystems and Coastal Biodiversity: 1.1 Oceans, seas, estuaries and coastal ecosystems; physical and chemical characteristics of marine environments. 1.2 Marine biodiversity and ecological significance; marine food chains and food webs. 1.3 Mangrove ecosystems: distribution, zonation and adaptations; seagrass ecosystems and ecological importance. 1.4 Coral reefs, salt marshes and Marine Protected Areas (MPAs) of India.	15
	2	Marine Microbiology and Marine Resources 2.1 Diversity of marine microorganisms, phytoplankton, seaweeds, seagrasses, marine invertebrates and vertebrates. 2.1 Marine algae (Chlorophyta, Phaeophyta and Rhodophyta) and their ecological significance. 2.3 Economic importance of marine resources: seaweeds, fisheries, bioactive compounds and marine biotechnology. 2.4 Marine environmental issues: coastal pollution, eutrophication, harmful algal blooms, ocean acidification and climate change impacts.	15
	3	Forestry and Forest Ecosystems 3.1 Scope and importance of forestry; classification and major forest types of India. 3.2 Forest ecosystem structure, stratification, succession and plant-soil interactions. 3.3 Forest biodiversity: mycorrhizae, endophytes, epiphytes, keystone and endangered species. 3.4 Forest resources: timber, non-timber forest products (NTFPs), medicinal plants and ethnobotanical importance of forests.	15
	4	Forest Conservation and Sustainable Management 4.1 Deforestation, forest degradation and biodiversity conservation strategies. 4.2 Protected areas, biosphere reserves, wildlife conservation and ecosystem restoration. 4.3 Social forestry, agroforestry, urban forestry and Joint Forest Management (JFM). 4.4 Forests and climate change: carbon sequestration, carbon budgeting, REDD+; applications of GIS, Remote Sensing and biotechnology in forest management.	15

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Suggested Reading:

1. Lee, R.E. (2008). Phycology (4th Edition). Cambridge: Cambridge University Press.
2. Karleskint, G., Turner, R. & Small, J. (2013). Introduction to Marine Biology (4th Edition). Belmont, California: Brooks/Cole Cengage Learning.
3. Levinton, J.S. (2017). Marine Biology: Function, Biodiversity, Ecology (5th Edition). New York: Oxford University Press.
4. Munn, C.B. (2020). Marine Microbiology: Ecology and Applications (3rd Edition). Boca Raton: CRC Press.
5. Champion, H.G. & Seth, S.K. (1968). A Revised Survey of the Forest Types of India. New Delhi: Government of India Press.
6. Trivedi, P.C. (2005). Forestry and Forest Ecology. Jaipur: Pointer Publishers.
7. Negi, S.S. (1994). Forests and Forestry in India. New Delhi: Indus Publishing Company.
8. Kimmins, J.P. (2004). Forest Ecology: A Foundation for Sustainable Forest Management (3rd Edition). Pearson Education.
9. Odum, E.P. & Barrett, G.W. (2005). Fundamentals of Ecology (5th Edition). Belmont, California: Thomson Brooks/Cengage Learning.
10. Sharma, P.D. (2021). Ecology and Environment (14th Edition). Meerut: Rastogi Publications.
11. Groom, M.J., Meffe, G.K. & Carroll, C.R. (2006). Principles of Conservation Biology (3rd Edition). Sunderland, Massachusetts: Sinauer Associates.
12. Kirchman, D.L. (Ed.) (2018). Microbial Ecology of the Oceans (3rd Edition). Hoboken, New Jersey: Wiley-Blackwell.
13. Forest Survey of India (Latest Edition). India State of Forest Report. Dehradun: Forest Survey of India, Ministry of Environment, Forest and Climate Change, Government of India.
14. Zoological Survey of India (Latest Edition). Marine Biodiversity of Indian Seas. Kolkata: Zoological Survey of India.

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Course Level	6.0		Internal Marks	30
Programme	M.Sc. Microbiology		External Marks	70
Semester	II		Practical Internal	--
Category of Course	Discipline Specific Course-203		Practical External	--
Course Credit	04		Prac. External Exam Duration	-
Teaching Hours	120		Total	100
Course Code			Exam Duration	2.30 Hrs.
Course Title	Bioinformatics and Bioethics (Theory)			

Course Objectives:

1. To introduce the concepts, tools and databases of bioinformatics used in modern biological research.
2. To develop understanding of sequence analysis, gene annotation, phylogenetics, structural bioinformatics and systems biology.
3. To familiarize students with bioethical principles, research ethics, publication ethics and ethical issues associated with emerging biological technologies.

Course Learning Outcomes: After completion of the course, students will be able to:

1. Retrieve, manage and analyze biological data using major bioinformatics databases and computational tools.
2. Perform sequence analysis, gene annotation and phylogenetic interpretation for biological research.
3. Apply computational approaches in structural biology, genomics, proteomics and systems biology.
4. Evaluate ethical issues related to biological research, scientific publications, biotechnology and emerging life science technologies.

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Course contents

DSC-203 Bioinformatics and Bioethics

Sem	Unit No.	Syllabi	Teaching Hours
2	1	Introduction to Bioinformatics and Biological Databases 1.1 Introduction, scope and applications of bioinformatics in biological sciences. 1.2 Biological databases: nucleotide, protein, gene expression, structural and pathway databases. 1.3 Database retrieval systems and major bioinformatics resources (NCBI, EMBL, DDBJ, PDB, UniProt). 1.4 Applications of bioinformatics in medicine, agriculture, biodiversity and biotechnology.	15
	2	Sequence Analysis and Gene Annotation 2.1 Nucleotide and protein sequences; sequence similarity and homology. 2.2 Pairwise and multiple sequence alignment; BLAST and FASTA. 2.3 Gene prediction and annotation in prokaryotic and eukaryotic systems. 2.4 Phylogenetic analysis, comparative genomics and applications in taxonomy and evolution.	15
	3	Structural Bioinformatics and Systems Biology 3.1 Protein structure organization and structural databases. 3.2 Molecular modelling, structure visualization and molecular docking. 3.3 Protein structure prediction: homology modelling, threading and AI-based approaches (AlphaFold). 3.4 Systems biology, biological networks, omics technologies and applications in health, agriculture and environmental sciences.	15
	4	Bioethics and Responsible Conduct of Research 4.1 Principles and importance of bioethics; ethical issues in biological and biomedical research. 4.2 Research and publication ethics: authorship, data ownership, conflict of interest, plagiarism, fabrication and falsification. 4.3 Ethics Committees and Regulatory Framework: Institutional Ethics Committee (IEC), Institutional Animal Ethics Committee (IAEC), Institutional Biosafety Committee (IBSC), CPCSEA and ethical guidelines for human and animal research. 4.4 Emerging ethical issues in life sciences: genetic engineering, cloning, stem cell research, genomics, personalized	15

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		medicine, Artificial Intelligence in research, data privacy and responsible innovation.	
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SEMESTER- I & II

Course Level	6.0	Internal Marks	-
Programme	M.Sc. Microbiology	External Marks	-
Semester	I	Practical Internal	30
Category of Course	Discipline Specific Elective Course-204	Practical External	70
Course Credit	04	Prac. External Exam Duration	4 Hrs.
Teaching Hours	120	Total	100
Course Code		Exam Duration	-
Course Title	Combined Practical-I (Analytical Techniques & Bioinformatics)		

Course Objectives:

1. To provide practical training in analytical and instrumental techniques used in biological sciences.
2. To develop skills in handling biological databases, sequence analysis and bioinformatics tools.
3. To enable students to interpret biological data generated through analytical and computational approaches.

Course Learning Outcomes: After completion of the course, students will be able to:

1. Operate basic analytical instruments and interpret experimental data.
2. Apply chromatographic, spectroscopic and electrophoretic techniques in biological research.
3. Retrieve, analyze and interpret biological information from public databases.
4. Perform sequence alignment, phylogenetic analysis and basic bioinformatics investigations.

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Suggested Practical Course Contents

DSC-204 Combined Practical-I

Sr. No.	Practical Exercise	Teaching Hours
1	Calibration and operation of a light microscope for proper observation and measurement of microscopic specimens.	120
2	Study of Beer–Lambert Law by determining the relationship between absorbance and concentration using a colorimetric assay.	
3	Estimation of protein concentration using UV–Visible spectrophotometry.	
4	Determination of DNA concentration and purity using spectrophotometric analysis.	
5	Separation and identification of amino acids using Paper Chromatography and Thin Layer Chromatography (TLC).	
6	Separation of cellular biomolecules and organelles using centrifugation techniques.	
7	Analysis of DNA samples through agarose gel electrophoresis and interpretation of banding patterns.	
8	Retrieval and analysis of nucleotide and protein sequences from NCBI, EMBL, and UniProt databases.	
9	Sequence similarity searching and homology analysis using the BLAST tool.	
10	Performing pairwise and multiple sequence alignments using bioinformatics software and online tools.	
11	Construction and interpretation of phylogenetic trees to study evolutionary relationships among organisms.	
12	Gene prediction and functional annotation using online bioinformatics resources and databases.	
13	Visualization and structural analysis of proteins using PDB resources and molecular visualization tools.	
14	Mini-project involving bioinformatics data analysis, interpretation, and scientific report preparation.	
15	Separation and analysis of plant pigments using Paper Chromatography and Thin Layer Chromatography (TLC).	

Suggested Reading:

1. Wilson, K. & Walker, J. Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.
2. Plummer, D.T. An Introduction to Practical Biochemistry. McGraw-Hill Education.
3. Sawhney, S.K. & Singh, R. Introductory Practical Biochemistry. Narosa Publishing House.

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4. Rastogi, S.C., Mendiratta, N. & Rastogi, P. Bioinformatics: Methods and Applications. PHI Learning.
5. Mount, D.W. Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.
6. Lesk, A.M. Introduction to Bioinformatics. Oxford University Press.

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Subject: Microbiology
SEMESTER- I & II

Course Level	6.0		Internal Marks	-
Programme	M.Sc. Microbiology		External Marks	-
Semester	I		Practical Internal	30
Category of Course	Discipline Specific Elective Course-205		Practical External	70
Course Credit	04		Prac. External Exam Duration	4 Hrs.
Teaching Hours	120		Total	100
Course Code			Exam Duration	-
Course Title	Combined Practical-II (Marine Biology, Forestry & Bioethics)			

Course Objectives:

1. To provide practical knowledge of marine and forest biodiversity and ecosystem analysis.
2. To develop skills in ecological sampling, biodiversity assessment and environmental monitoring.
3. To familiarize students with ethical practices, responsible conduct of research and scientific integrity.

Course Learning Outcomes: After completion of the course, students will be able to:

1. Identify major marine and forest organisms and evaluate their ecological significance.
2. Perform vegetation analysis and biodiversity assessment using standard ecological methods.
3. Analyze environmental parameters related to marine and forest ecosystems.
4. Apply ethical principles and responsible research practices in biological sciences.

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Suggested Practical Course Contents

DSC-105 Combined Practical-II

Sr. No.	Practical Exercise	Teaching Hours
1	Study and identification of representative marine algae belonging to Chlorophyta, Phaeophyta, Rhodophyta, and economically important seaweeds.	120
2	Study of mangrove and seagrass species with reference to their adaptations and ecological significance.	
3	Analysis of marine and aquatic water samples for salinity and pH determination.	
4	Estimation of chlorophyll content in marine algae and aquatic plants.	
5	Preparation of herbarium specimens of marine algae, mangrove plants, and selected forest species.	
6	Identification and documentation of major forest tree species, medicinal plants, and Non-Timber Forest Products (NTFPs).	
7	Vegetation analysis using the quadrat method for determination of Frequency, Density, Abundance, and Importance Value Index (IVI).	
8	Assessment of species diversity using Shannon–Wiener and Simpson diversity indices.	
9	Estimation of biomass and carbon sequestration potential of selected tree species.	
10	Biodiversity documentation and assessment of a selected forest or coastal ecosystem.	
11	Analysis of case studies on research ethics, publication ethics, plagiarism, and scientific misconduct.	
12	Preparation and interpretation of plagiarism reports using plagiarism detection software.	
13	Evaluation of ethical issues in genetic engineering, cloning, stem cell research, and artificial intelligence in biological sciences.	
14	Preparation of an ethics review checklist for biological research proposals.	
15	Field visit to a mangrove forest, forest ecosystem, or biodiversity conservation area and submission of a field report.	

Suggested Reading:

1. Pandey, B.P. Practical Microbiology. S. Chand & Company Ltd.
2. Yadav, R.P. A Textbook of Practical Microbiology. Rastogi Publications.
3. Jain, S.K. & Sinha, S.C. Practical Plant Ecology. CBS Publishers & Distributors.
4. Greig-Smith, P. Quantitative Plant Ecology. Blackwell Scientific Publications.
5. Forest Survey of India. National Forest Inventory Manual. Forest Survey of India, Dehradun.

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6. Lee, R.E. Phycology. Cambridge University Press.
7. Karleskint, G., Turner, R. & Small, J. Introduction to Marine Biology. Brooks/Cole Cengage Learning.
8. Macrina, F.L. Scientific Integrity: Text and Cases in Responsible Conduct of Research. ASM Press.
9. Sateesh, M.K. Bioethics and Biosafety. I.K. International Publishing House.
10. Goel, D. & Parashar, S. IPR, Biosafety and Bioethics. Pearson Education India.

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Course Level	6.0		Internal Marks	-
Programme	M.Sc. Microbiology		External Marks	-
Semester	II		Practical Internal	15
Category of Course	Skill Enhancement Course-201		Practical External	35
Course Credit	02		Prac. External Exam Duration	2 Hrs.
Teaching Hours	60		Total	50
Course Code			Exam Duration	
Course Title	Artificial Intelligence in Biological Sciences			

Course Objectives: By completing the course:

1. To understand the fundamental concepts and applications of Artificial Intelligence (AI) and Machine Learning (ML) in biological sciences and research.
2. To develop skills in the use of AI-based tools, biological databases, bioinformatics resources, and data visualization platforms for biological data analysis.
3. To apply AI-assisted approaches for literature mining, data interpretation, predictive analysis, and problem-solving in biological sciences.

Course Learning Outcomes: After completion of the course, students will be able to:

1. Apply AI tools and bioinformatics resources for data retrieval, analysis, visualization, and interpretation of biological information.
2. Utilize AI-assisted platforms for literature review, biological data management, and predictive modeling in biological research.
3. Demonstrate the use of AI technologies in solving biological problems and supporting research, innovation, and decision-making processes.

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Suggested Practical Course Contents

SEC-201

Sr. No.	Practical	Teaching Hours
1	Introduction to Artificial Intelligence tools and platforms used in biological sciences.	60
2	Creating effective prompts for obtaining biological information using AI assistants.	
3	AI-assisted literature search and retrieval of scientific information from online databases.	
4	AI-based summarization of scientific articles and preparation of literature notes.	
5	Identification and extraction of keywords, research gaps, and objectives from published research papers using AI tools.	
6	Generation and formatting of scientific references using AI-assisted citation management tools.	
7	Retrieval of nucleotide and protein sequence information from biological databases (NCBI, UniProt).	
8	Sequence similarity search using BLAST and interpretation of results.	
9	Multiple sequence alignment using online bioinformatics tools.	
10	Construction and interpretation of phylogenetic trees using AI-supported or online platforms.	
11	AI-assisted identification of plant species using image recognition applications.	
12	AI-assisted identification of animal species and insects using digital image-based tools.	
13	AI-assisted identification and classification of microorganisms using online resources and databases.	
14	Retrieval and analysis of biodiversity information from GBIF and related databases.	
15	Analysis of ecological and environmental datasets using AI-assisted tools.	
16	Preparation of graphs, charts, and scientific visualizations from biological datasets using AI tools.	
17	AI-assisted statistical analysis and interpretation of biological data.	
18	Species distribution mapping using GIS and AI-enabled platforms.	
19	AI-assisted prediction of species occurrence and habitat suitability using available datasets.	

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Sr. No.	Practical	Teaching Hours
20	Extraction, organization, and visualization of biological data in spreadsheets using AI support.	
21	Preparation of scientific reports, posters, and presentations using AI-assisted platforms.	
22	Detection of plagiarism and evaluation of AI-generated scientific content.	
23	Study of ethical issues, limitations, biases, and responsible use of AI in biological sciences.	
24	Mini-project: AI-assisted analysis of a biological dataset/research problem and presentation of findings.	
25	Submission and presentation of practical report/project.	

Suggested Readings

1. Russell, S. and Norvig, P. Artificial Intelligence: A Modern Approach. Pearson Education.
2. Lesk, A.M. Introduction to Bioinformatics. Oxford University Press.
3. Mount, D.W. Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.
4. Xiong, J. Essential Bioinformatics. Cambridge University Press.
5. Agrawal, P.K. and Agrawal, P. Artificial Intelligence in Biological Sciences. CRC Press.
6. Brown, T.A. Genomes. Wiley-Blackwell.
7. National Center for Biotechnology Information (NCBI): Tutorials and Resources.
8. UniProt Knowledgebase and GBIF User Guides.

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PAPER STYLE: 4 CREDIT PAPERS

Time: 2.30 Hours

Total Marks: 70

Instructions:

1. Illustrate your answer with neat and labelled diagrams.
2. Figure on the right side indicates the full marks of the questions.

Structure of the External Question Paper

Q 1. (A) Answer the following questions	14 Marks
1. Describe...	07
2. Write a note	07
Or	
Q.1 (B) Answer the following questions	
1. Write a note	07
2. Describe....	07
Q 2. (A) Answer the following questions	14 Marks
1. Describe...	07
2. Write a note	07
Or	
Q.2 (B) Answer the following questions	
1. Write a note	07
2. Describe...	07
Q 3. (A) Answer the following questions	14 Marks
1. Describe...	07
2. Write a note	07
Or	
Q.3 (B) Answer the following questions	
1. Write a note	07
2. Describe....	07
Q 4. (A) Answer the following questions	14 Marks
1. Describe...	07
2. Write a note	07
Or	
Q.4. (B) Answer the following questions	
1. Write a note	07
2. Describe....	07
Q. 5. Do as direct (any seven out of ten questions)	14 Marks
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	

Note: Questions 1, 2,3, and 4 from each respective unit and question 5 from all four units.

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Subject: Microbiology
SEMESTER- I & II

INTERNAL EVALUATION SCHEME

Sr. No.	Evaluation Component	4-Credit Subjects (Marks)	2-Credit Subjects (Marks)
1	Assignments, seminars, quizzes, mid-term tests, lab records, presentations, Term Paper, Viva-voce, Projects/Surveys/Field visits, Journal Writing (Any three —5 marks each for 4-credit; anyone — 5 marks for 2-credit)	15	05
2	Mid-Term Evaluation	15	10
TOTAL		30	15

ASSESSMENT BY UNIVERSITY			
Que. No.	Particulars	Marks	
		70	35
EXTERNAL EXAMINER			
1	Perform any three or four or five practicals from the given list of exercises as per the instructions of the examiner	60	30
2	Viva-voce	10	05
Total		50	35