SIKKIM UNIVERSITY

(A Central University Established by an Act of Parliament of India, 2007)

LEARNING OUTCOME - BASED CURRICULUM

Ph.D. (MICROBIOLOGY) SYLLABUS

(Course Work)

(With effect from Academic Session 2023-24)

DEPARTMENT OF MICROBIOLOGY

SIKKIM UNIVERISTY

6th MILE, TADONG - 737102

GANGTOK, SIKKIM, INDIA

TABLE OF CONTENTS

Learning Outcomes-Based Curriculum Framework (LOCF) for Doctor of Philosophy Programme in Microbiology of Sikkim University

Preamble

The Doctor of Philosophy programme in Microbiology is a research-based degree that explores living creatures at the molecular level and includes a thorough examination of biomolecules. This advanced degree combines several Biological Sciences topics, including Genetics, Biotechnology, Medicine, Immunology, and Biochemistry.

PhD in Microbiology is a three-year degree programme. Eligibility criteria for candidates to apply for the programme will be M.Sc. in Microbiology / Bio- Technology with 55% marks in aggregate.

1. Introduction

The learning outcomes-based curriculum framework (LOCF) for Doctor of Philosophy Programme in Microbiology of Sikkim University will have courses harnessing both fundamental and advanced areas of the subject. Total credits for the programme are 14. The programme aims to impart conceptual clarity to the students for both the theory and practical subjects.

2. Program Learning Outcomes

PLO1: Acquire considerable knowledge of various domains of Microbiology and fundamental concepts in specialised areas of food, environmental and industrial microbiology.

PLO2: Develop analytical and problem-solving skills by applying the concepts learned from different courses in Microbiology.

PLO3: Acquaint students with contemporary research in various basic and applied fields of Microbiology.

3. Mode of Evaluation/Assessment:

Students will be evaluated in each Semester through Sessional Tests and End Semester Examination.

COURSE CONTENTS

Course Code	Course Name	Course	Credits	Total Marks	Internal marks	External marks
MIC-C-701	Research Methodology	Core	4	100	50	50
***MIC-E-702**	Medical Microbiology	Elective	4	100	50	50
***MIC-E-703**	Food Microbiology	Elective	4	100	50	50
***MIC-E-704**	Environmental Microbiology	Elective	4	100	50	50
***MIC-E-705**	Industrial Microbiology	Elective	4	100	50	50
MIC-C-706	Research proposal	Core	4	100	50	50
MIC-C-707	Research And Publication Ethics (RPE)	Core	2	50	25	25
	Total		**14**	**350**	**175**	**175**

(*) - Candidate has to opt any one paper depending on their choice of specialization.

MIC-C-701
RESEARCH METHODOLOGY

Semester: First Semester **Course Level: 700** **Total Marks: 100**
L+T+P: 3+1+0 = 4 Credits **Lecture: 45 Hrs + Tutorial: 15 Hrs + Practical: 0 Hrs**

Course Learning Objectives:
Upon completion of the course students will be able to:

CLO1: Students will learn about research designs, sampling procedures and framing research questions and hypothesis.
CLO2: Learners will be acquainted with basic concepts of statistics and tools to analyse data.
CLO3: Students will learn about the various inferential and predictive data analysis methods.
CLO4: Students will learn about the preparation of scientific communications and the use of reference manager software's.

UNIT I: RESEARCH DESIGN AND DATA COLLECTION
Research methodology: different types of research design, Sampling methods- procedures of sampling, criteria of selecting a sample and different types of sampling designs. Primary and secondary data. Framing research questions and developing hypotheses.

UNIT II: PROCESSING AND ANALYSIS OF DATA
Processing operations: Elements/types of analysis, usefulness of statistics in research, dispersion, Correlation and regression analysis: Bivariate and multivariate correlation, concepts of linear and higher order regression, multivariate regression, regression models, Introduction to computer-based programming in data analysis such as R.

UNIT III: HYPOTHESES TESTING AND BIOSTATISTICS
Basic concepts of hypothesis testing, Parametric and Non-parametric tests, Normality tests, F and t-tests, Mann- Whitney U test, Chi square test, ANOVA (One Way and two way), MANOVA, ANCOVA, Kruskal-Wallis one way ANOVA, Ordination techniques: PCA, PCoA, CCA, NMDS.

UNIT IV: SCIENTIFIC WRITING
Types of scientific documents, guidelines for preparation of scientific articles/documents, identification of journals, referencing and reference management tools, Review articles: types of review (narrative, systematic and meta-analysis)

SUGGESTED TEACHING LEARNING STRATEGIES

1. Lecture-cum discussion, library readings, critical discussion.
2. Organizing philosophical debates and group discussions, case studies, projects.
3. Individual presentations by student on selected topic.

ASSESSMENT FRAMEWORK

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50%	Class Test, Article Writing, Assignment	Group Discussion, Quiz	Presentation, Seminars
Summative Marks: 50%	Semester examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO

Suggested Readings:

1. 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.
2. CSIR (2019). *CSIR Guidelines for Ethics in Research and in Governance*. Council of Scientific and Industrial Research, New Delhi.
3. Kothari, C.R. and Garg, G. (2019). *Research Methodology*. New Delhi: New Age International Publishers. 1-480. ISBN-13: 978-9386649225.

MIC-E-702

EMERGING AREAS OF RESEARCH IN MEDICAL MICROBIOLOGY

Semester: First Semester **Course Level: 700** **Total Marks: 100**
L+T+P: 3+1+0 = 4 Credits **Lecture: 45 Hrs + Tutorial: 15 Hrs + Practical: 0 Hrs**

Course Learning Outcomes

Upon completion of the course students will be able to:

CLO1: Students will be familiar with techniques commonly used in medical microbiology.

CLO2: Students will be able to classify the viruses according to ICTV and Bergey's manual and understand the working principle of the diagnostic methods

CLO3: This course also enables students in techniques used commonly used in the gene manipulations.

CLO4: Learners will also be acquainted with techniques used in phenotypic and genotypic and genomic sequencing to study bacteria and fungi.

Unit I: Microbiological Techniques
Aseptic techniques: (Physical and chemical methods of Sterilization and Disinfection), Isolation and pure culture Techniques, Staining (Simple staining, Gram staining, Capsule, Spore and Acid fast staining), Sample selection, Sample collection and Sample transportation. Techniques of Culture Preservation. Antibiotic susceptibility techniques: Disc diffusion method and Minimum Inhibitory Concentration. An overview of Biosafety, Institutional Biosafety Committee, Institutional Ethical Committee. Biodiversity Act.

Unit II: Study of significant human pathogens
Human illness and infection processes. Pathogenesis, Clinical feature, classification and Laboratory diagnosis of important bacterial, viral, fungal and parasitic diseases. Molecular approaches for detecting and diagnosing of pathogenic microorganisms. Vaccination and immunization (Types of vaccines, General concept of immune responses, B and T lymphocytes).

Unit III: Advanced Techniques in Microbiology-I
Genomic DNA extraction and Purification, Polymerase Chain Reaction (PCR), Gel electrophoresis, Real-Time PCR (RT-PCR). Denaturing Gradient Gel Electrophoresis (DGGE), Restriction Fragment Length Polymorphism (RFLP).

Unit IV: Advanced Techniques in Microbiology-II
Phenotypic (Simple microscope, Compound microscope, Electron microscope) and Genotypic Identification of bacteria and fungi (16S ribosomal RNA (rRNA), Internal Transcribed Spacer (ITS) Sequencing, Metagenomic approaches (Amplicon sequencing, Shotgun sequencing).

Suggested teaching learning strategies:

- Lecture-cum discussion: Lectures on the recent advancements in the medical microbiology will be held followed by discussions.
- Problem-Based Learning: Assignment will be provided to enhance problem solving skill of the students.
- Journal Club: Students will read research articles and prepare presentations which examined by course teacher to check students' knowledge, analytical skill in the field of medical microbiology.

Assessment framework:

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50	Class Test, Class Assignment, Self-Test, Online Test	*Viva-Voce*, Group Discussion	Presentation, Seminars, Journal Club
Summative Marks: 50	Semester-end examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested Readings:

1. Brooks, G., Carroll, K. C., Butel, J. & Morse, S. (2007). *Jawetz, Melnick & Adelberg's Medical Microbiology*, 24th edition. New York: McGraw-Hill Education. 1-832. ISBN-13: 978-0071476669.
2. Chakraborty P. (2013). *A Textbook of Microbiology*. 3rd edition. India: New Central Book Agency (P) Limited. 1-798. ISBN-13: 978-8173818769.
3. Collee, J.G., Fraser, A. G., Marmion, B. P. & Simmons, A. (2011). *Mackie & McCartney Practical Medical Microbiology*, 14th edition, USA: Elsevier. 1-992. ISBN-13: 978-8131203934.
4. Dimmock, N. J., Easton, A. J., & Leppard, K. N. (2015). *Introduction to modern virology*. Hoboken, New Jersey: Wiley- Blackwell. 1-526.
5. Forbes, B. A., Sahm, D. F. & Weissfeld, A. S. (2007), *Bailey and Scott's Diagnostic Microbiology*. 12th edition, USA: Mosby. 1-1056. ISBN-13: 978-0323030656.
6. Kapil A., & Paniker A. (2013). *Textbook of Microbiology*. 9th Edition, Hyderabad, India: Orient Blackswan, 1-720. ISBN: 9788173718892, 817371889X

MIC-E-703

FOOD MICROBIOLOGY (FERMENTED FOODS)

Semester: First Semester	**Course Level: 700**	**Total Marks: 100**
L+T+P: 3+1+0 = 4 Credits	**Lecture: 45 Hrs + Tutorial: 15 Hrs + Practical: 0 Hrs**	

Course Learning Outcomes:

CLO1: Students will understand the importance of 'ethno-microbiological' knowledge of the ancient people on production of fermented foods with modern interpretation of metagenomes and biomarkers for several health promoting benefits to the consumers.

CLO2: Learners will also be aware of recent methods to study fermented foods through culture dependent and independent techniques.

CLO3: Students will learn about the application of omics – genomics, proteomics and metabolomics to study food.

CLO4: Students will be learn about the formulations of various pre and probiotics for different applications

Unit 1: Fermented foods of the world

Gastronomical distribution and classification of major global fermented foods and alcoholic beverages. 'Ethno-microbiology' concept of indigenous fermented foods. Some clinically tested popular health-promoting fermented foods of the world: cheese, *kombucha, kefir*, *kimchi, sourdough*, *yogurt* and probiotic drink.

Unit 2: Microbial Community Structures in Fermented Foods

Culture dependent methods: Molecular identification; Whole Genome Sequencing – De novo sequencing and Resequencing (reference-based sequencing). Culture-independent techniques: high-throughput amplicon sequencing; shotgun sequencing and metagenome-assembled genomes. Role of domains in food fermentation: Bacteria, Eukaryotes (Yeasts, Moulds), Viruses and Archaea. Culture Collections and creation of Accession numbers for sequences.

Unit 3: Multi-omics of Fermented Foods

Foodomics: concept and methodology of proteomics, metabolomics, transcriptomics, and volatolomics. Biomarkers and signatures genes for health-promoting benefits of fermented foods. Preventive and therapeutic properties of fermented foods against human diseases: cancer, neurogenerative, diabetes, cardiovascular disease, obesity, gastrointestinal disorder.

Unit 4: Probiotics and Gut Microbiota

Current classification of probiotic microorganisms -bacteria and yeasts. Effects of prebiotics on gut microbiota and host health. Role of gut microbiota in nutrition and health benefits. Effect of fermented foods on gut microbiota with reference to the consumption of some clinically tested global functional fermented foods. Protocols for studies of health claims of functional foods on the basis of animal and human/clinical trials.

Suggested teaching learning strategies:

- Lecture-cum discussion: Lectures on the recent advancements in the food microbiology will be held followed by discussions.
- Problem-Based Learning: Assignment will be provided to enhance problem solving skill of the students.
- Journal Club: Students will be provided with scientific papers and make presentation to enhance knowledge, analytical skill in the related field.

Assessment framework:

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50	Class Test, Class Assignment, Self-Test, Online Test	*Viva-Voce*, Group Discussion	Presentation, Seminars, Journal Club
Summative Marks: 50	Semester-end examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested Readings:

1. Cunningham, M., Azcarate-Peril, M.A., Barnard, A., Benoit, V., Grimaldi, R., Guyonnet, D., Holscher, H.D., Hunter, K., Manurung, S., Obis, D., Petrova, M.I., Steinert, R.E., Swanson, K. S., van Sinderen, D., Vulevic, J. and Gibson, G.R. (2021). Shaping the future of probiotics and prebiotics. *Trends in Microbiology* 29 (8): 667–685). doi.org/10.1016/j.tim.2021.01.003
2. Leeuwendaal, N.K., Stanton, C., O'Toole, P.W. and Beresford, T. P. (2022). Fermented foods, health and the gut microbiome. *Nutrients* 14(7):1527. doi: 10.3390/nu14071527.
3. Shi, H., An, F., Lin, H., Li, M., Wu, J. and Wu, R. (2022). Advances in fermented foods revealed by multi-omics: A new direction toward precisely clarifying the roles of microorganisms. *Frontiers in Microbiology* 13:1044820. doi: 10.3389/fmicb.2022.1044820
4. Tamang, J.P., Cotter, P., Endo, A., Han, N.S., Kort, R., Liu, S.Q., Mayo, B., Westerik, N. and Hutkins, R. (2020). Fermented foods in a global age: east meets west. *Comprehensive Reviews in Food Science and Food Safety* 19: 184-217. doi: 10.1111/1541-4337.12520
5. Tamang, J.P. (2022). "Ethno-Microbiology" of ethnic Indian fermented foods and alcoholic beverages. *Journal of Applied Microbiology* 133: 145-161.doi:10.1111/jam.15382.
6. Valdés, A., Álvarez-Rivera, G., Socas-Rodríguez, B., Herrero, M., Ibáñez, E. and Cifuentes, A. (2022). Foodomics: analytical opportunities and challenges. *Analytical Chemistry* 94 (1): 366-381.doi: 10.1021/acs.analchem.1c04678.
7. Yilmaz, B., Elibol, E., Shangpliang, H.N.J., Ozogul, F. and Tamang, J.P. (2022). Microbial communities in home-made and commercial *kefir* and their hypoglycaemic properties. *Fermentation* 8, 590.doi.org/10.3390/fermentation8110590.

MIC-E-704
ENVIRONMENTAL MICROBIOLOGY

Semester: First Semester **Course Level: 700** **Total Marks: 100**
L+T+P: 3+1+0 = 4 Credits **Lecture: 45 Hrs + Tutorial: 15 Hrs + Practical: 0 Hrs**

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

CLO1: Understand the diversity and advancements in the field of environmental microbiology and importance of phytochemicals.

CLO2: Learn about various techniques which are employed in environmental microbiology and phytochemicals research.

CLO3: Students will be able to design research proposals based on the theoretical concepts of the course paper on environmental microbiology.

CLO4: Learn about the diversity of extremophiles and its applications

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Unit I: Microbiological Techniques
Aseptic techniques: Physical and chemical methods of sterilization and disinfection). Isolation and pure culture techniques. Staining (Simple staining, Gram staining, capsule, spore and acid fast staining. Sample selection, sample collection and sample transport. Culture preservation techniques. Antibiotic susceptibility testing techniques: disc diffusion and minimum inhibitory concentration. Brief overview of Biosafety, Institutional Biosafety Committee, Institutional Ethical Committee.

Unit II: Instrumentation Techniques
Polymerase Chain Reaction (PCR); Recombinant DNA techniques; Restriction Fragment Length Polymorphism (RFLP); Denaturing/ Temperature Gradient Gel Electrophoresis (DGGE/TGGE); Sanger Sequencing; Pyrosequencing; High-performance liquid chromatography (HPLC); High-performance thin layer chromatography (HPTLC); Gas chromatography–mass spectrometry (GC-MS); Liquid chromatography-mass spectrometry (LC-MS).

Unit III- Recent perspectives of phytochemicals as antimicrobial agents
Recent perspectives on the use of phytochemicals as antimicrobial agents. Concepts on genomes and metabolic pathways of herbs. Recent developments in medicinal plant genomics.

Unit IV: Extreme environments of Himalayan regions
Glaciers, hot springs. Extremophiles: Introduction, diversity, habitat, physiology and applications of extremophiles. Microbiome of extreme environments. Methods in microbial ecology: Enrichment and isolation methods, microbial activity measurements.

Suggested teaching learning strategies:

- Lecture-cum discussion: Lectures on the recent advancements in the environmental microbiology including phytochemicals will be held followed by discussions.
- Problem-Based Learning: Assignment will be provided to enhance problem solving skill of the students.
- Journal Club: Students will read research articles and prepare presentations which examined by course teacher to check students' knowledge, analytical skill in the field of environmental microbiology.

Assessment framework:

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50	Class Test, Class Assignment, Self-Test, Online Test	Viva-Voce, Group Discussion	Presentation, Seminars, Journal Club
Summative Marks: 50	End-semester examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested Readings:

1. Alami M. M., Ouyang Z., Zhang Y., Shu S., Yang G., Mei Z. and Wang X. (2022). The Current Developments in Medicinal Plant Genomics Enabled the Diversification of Secondary Metabolites' Biosynthesis. *International Journal of Molecular Sciences.* 23(24):15932. doi: 10.3390/ijms232415932.
2. Chakraborty P. (2018). Herbal genomics as tools for dissecting new metabolic pathways of unexplored medicinal plants and drug discovery. *Biochimie Open*. (6) 9-16. doi: 10.1016/j.biopen.2017.12.003.
3. Dhakar K. and Pandey A. (2020). Microbial Ecology from the Himalayan Cryosphere Perspective. *Microorganisms*. 8(2):257. doi: 10.3390/microorganisms8020257.
4. Durvasula, R. V. and Subba Rao, D. V. (Eds.) (2020). Extremophiles from Biology to Biotechnology. First edition. CRC Press. ISBN 9780367572327.
5. Hoffman, A. and Clokie, S. (Eds.) (2018). Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press, Cambridge. 8th edition. ISBN-10 : .1107162270 .
6. Khare T., Anand U., Dey A., Assaraf Y.G., Chen Z.S., Liu Z. and Kumar V. (2021). Exploring Phytochemicals for Combating Antibiotic Resistance in Microbial Pathogens. *Frontiers in Pharmacology.* 12:720726. doi: 10.3389/fphar.2021.720726.

MIC-E-705
INDUSTRIAL MICROBIOLOGY

Semester: First Semester **Course Level: 700** **Total Marks: 100**
L+T+P: 3+1+0 = 4 Credits **Lecture: 45 Hrs + Tutorial: 15 Hrs + Practical: 0 Hrs**

Course Learning Outcomes:

Upon completion of the course students will be able to:

CLO1: Develop critical thinking skills through the analysis and interpretation of scientific literature in the field of industrial microbiology.

CLO2: To demonstrate an understanding of the fundamental concepts of industrial microbiology, including microbial growth, metabolism, and fermentation kinetics.

CLO3: Apply their knowledge of microbial growth and fermentation kinetics to the design and optimization of bioprocess systems.

CLO4: Analyse and evaluate the advantages and disadvantages of different fermentation technologies for microbial products.

Unit I: Introduction to Industrial Microbiology

An introduction to fermentation process. Screening of industrial microbes-Detection and assay of fermentation products. Classification of fermentation types. Metabolic engineering. Strain selection and improvement, mutation-protoplast fusion and recombinant DNA technique for strain development. Preservation methods of cultures. Current development and emerging areas in Industrial microbiology research.

Unit II: Microbial growth and Fermentation kinetics:

Batch kinetics –single substrate, dual substrates – sequential utilization, multiple substrates - simultaneous utilization, substrate inhibition, product synthesis (primary and secondary metabolite), toxic inhibition, death constant. Fed-batch kinetics-fixed volume, variable volume and cyclic fed-batch, applications and examples of fed-batch systems. Continuous cultivation system-applications and examples of continuous cultivation system; comparison between various cultivation systems.

Unit III: Bioprocess System:

Bioprocess Technology. Types of Fermenters. Fermentation in batch culture: Media formulation, Solid State and submerged fermentation; mechanically & non-mechanically agitated fermenters. Fermentation processes: optimization, and factors affecting downstream processing and recovery.

Unit IV: Fermentation technology for microbial products

Fermentative production of antibiotics (Penicillin), Solvents (Ethanol), Biopolymer (PHAs) and Recombinant DNA products e.g. Insulin and amylase. Mixed Acid Fermentation. Industrial application of enzymes, Carbohydrate Active Enzymes (cellulases & xylanases), Production of biofuels. Enzyme immobilization and different techniques used for immobilization and cell-based biotransformation.

Suggested teaching learning strategies:

- Lecture-based Approach: Start with lectures to introduce students to the basic concepts and principles of industrial microbiology. Use presentation slides, case studies, and examples to enhance understanding.
- Assignments and Assessments: Assign research papers or presentations on topics related to industrial microbiology to encourage students to explore specific applications and deepen their understanding.
- Demonstration Experiments: Conduct live demonstrations of small-scale fermentations and its different parts.
- Journal Club: Students are encourage to present recently published research papers to publicize cutting-edge research and practices in the field.

Assessment framework:

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50	Class Test, Class Assignment, Self-Test, Online Test	Viva-Voce, Group Discussion	Presentation, Seminars, Journal Club
Summative Marks: 50	Semester-end examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested Readings:

1. Boro M., Verma A.K., Chettri D., Yata V.K., & Verma A.K. (2022). Strategies involved in biofuel production from agro-based lignocellulose biomass. Environmental Technology & Innovation. doi: 10.1016/j.eti.2022.102679
2. Chettri, D., Sharma B., Verma A.K., & Verma A.K. (2021). Significance of Microbial Enzyme Activities in Agriculture. In Microbiological Activity for Soil and Plant Health Management, pp. 351-373. Springer, Singapore, 2021. https://doi.org/10.1007/978-981-16-2922-8_15.
3. Goyal A., & Sharma K. (2023). Glycoside Hydrolases: Biochemistry, Biophysics, and Biotechnology, 1st Edition. Elsevier
4. Mosier, N. S., & Ladisch, M. R. (2011). Modern biotechnology: connecting innovations in microbiology and biochemistry to engineering fundamentals. John Wiley & Sons.
5. Verma P. (2022). Industrial Microbiology and Biotechnology. Springer Singapore. doi: 10.1007/978-981-16-5214-1
6. Willaert R.G. (2020). Stress Biology of Yeasts and Fungi Applications for Industrial Brewing and Fermentation. Mdpi AG. doi: 10.3390/fermentation6030075

MIC-C-706
RESEARCH PROPOSAL

Semester: First Semester **Course Level: 700** **Total Marks: 100**
L+T+P: 3+1+0 = 4 Credits **Lecture: 45 Hrs + Tutorial: 15 Hrs + Practical: 0 Hrs**

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

CLO1: Learn to prepare scientific research proposal based on overview of published research on specific area(s) of research.

CLO2: Students will be familiar with published reports/articles/reviews/patents in the field of specific areas of Microbiology.

CLO3: Students will learn about research design and its types.

CLO4: Students will be familiar with biosafety and ethical issues in the field of Microbiology

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Units I: Literature search
Background of literature research and review; Systematic review; Literature on the intended area of research in microbiology.

Units II: Research design
Research objectives, Different types of research design (experimental design, sampling design) Various methods for collection of data.

Units III: Citations/Bibliography
Citations/Bibliography and Different tools for citation; Plagiarism and use of plagiarism software like Turnitin, Urkund; Copy rights; Publication ethics; Impact factor and citation index

Units IV: Biosafety and Ethical issues
Institutional Biosafety Committees; Biosafety rules and regulations in the field of microbiology, Regulations guidelines for recombinant DNA technology; genetically modified starter cultures. Institutional Ethical Committees; regulation for animal and human clinical trials in India; consent from human subjects.

Suggested teaching learning strategies:

- Lecture-cum discussion: Lectures on the recent advancements in the food microbiology will be held followed by discussions.
- Problem-Based Learning: Assignment will be provided to enhance problem solving skill of the students.

Assessment framework:

Assessment	Written Modes	Oral Modes	Integrated Modes
Formative Marks: 50	Class Test, Class Assignment, Self-Test, Online Test	Viva-Voce, Group Discussion	Presentation, Seminars, Journal Club
Summative Marks: 50	End-semester examinations conducted by the university will be considered the mode of summative assessment.		

Note: Teachers can choose any mode of formative assessment as per nature of the CLO.

Suggested Readings:

1. Kothari, C.R. and Garg, G. (2019). *Research Methodology*. New Delhi: New Age International Publishers. 1-480. ISBN-13: 978-9386649225
2. Pruzan, P (2018). *Research Methodology: The Aims, Practices and Ethics of Science,* Springer. 1-326. ISBN-13: 3319800844-978
3. UGC Notification (2018). University Grants Commission (Promotion Of Academic Integrity And Prevention Of Plagiarism In Higher Educational Institutions) Regulations, 2018, UGC, New Delhi.
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. Beall, J: (2012) Predatory publishers are corrupting open access. Nature, 489(7415), 179-179. https://doi.org/10.1038/489179a
6. Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance (2019), ISBN:978-81-939482-1-7. htt://www.insaindia.res.in/pdf/Ethics_Book.pdf.

MIC-C-707
RESEARCH AND PUBLICATION ETHICS (RPE)

Semester: First Semester **Course Level: 700** **Total Marks: 50**
L+T+P: 2+0+0 = 2 Credits **Lecture: 30 Hrs + Tutorial: 0 Hrs + Practical: 0 Hrs**

Course Learning Outcome:
Upon completion of the course students will be able to:

CLO1: Students will be aware of the ethics, moral values and standards in research.
CLO2: Design their own research plan and infer the ethics involved in their research.
CLO3: Determine and follow ethical guidelines in human and animal experimentation.
CLO4: Recognize and use open access publishing, databases, and learn research metrics

Unit I: SCIENTIFIC CONDUCT AND PUBLICATION ETHICS
Ethics with respect to science and research
Intellectual honesty and research integrity
Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP)
Redundant publications: duplicate and overlapping publications, salami slicing
Selective reporting and misrepresentation of data.
Best practices /Standards setting initiatives and guidelines: COPE, WAME, etc.
Conflicts of interest
Violation of publication ethics, authorship and contributorship
Identification of publication misconduct, complaints and appeals
Predatory publishers and journals
Welfare of animals used in research, ethics in research involving human experimentation
Institutional ethical committee, Institutional animal ethics committee and Biosafety committee: roles and responsibilities

Unit II: OPEN ACCESS PUBLISHING, DATABASES AND RESEARCH METRICS
Concept of Open Educational Resources (OER), concept of open license, open access publishing, open access content management
Databases: Indexing databases, Citation databases: Web of Science, Scopus, etc.
Research Metrics: Impact Factor of Journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score: Metrics: h-index, g index, i10 index, altmetrics, ISBN, ISSN UGC CARE list journals, latest UGC regulations on academic integrity

SUGGESTED TEACHING LEARNING STRATEGIES
As per MOOCS.

ASSESSMENT FRAMEWORK
Average assignment score = 25% of average of best 6 assignments out of the total 8 assignments given in the course.
Exam score = 75% of the proctored certification exam score out of 50
Final score = Average assignment score + Exam score

Suggested Readings:

1. Bird, A. (2006). Philosophy of Science. Routledge Maclntyre,
2. 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 Science, 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), Ethics in Science Education, Research and Governance (2019), ISBN:978-81-939482-1-7. htt://www.insaindia.res.in/pdf/Ethics_Book.pdf.

SYLLABUS REVIEW COMMITTEE

Sl. No.	Name & Designation	
1	**Professor Dr. Jyoti Prakash Tamang** Senior Professor & Head Department of Microbiology Sikkim University	Chairman
2	**Dr. Nagendra Thakur** Associate Professor Department of Microbiology Sikkim University	Member
3	**Dr. Buddhiman Tamang** Assistant Professor Department of Microbiology Sikkim University	Member
4	**Dr. Bimala Singh** Assistant Professor Department of Microbiology Sikkim University	Member
5	**Dr. Anil Kumar Verma** Assistant Professor Department of Microbiology Sikkim University	Member
6	**Dr. Meera Ongmu Bhutia** Guest Faculty Department of Microbiology Sikkim University	Member
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The revised PhD syllabus of Microbiology has been reviewed by eminent Experts - Prof. Dr. Rup Lal, *FNA* Retired Professor, University of Delhi and Prof. Dr. D. J. Bagyaraj, *FNA*, NASI Hon. Scientist & Chairman, CNBRCD.