DDU Gorakhpur University, Gorakhpur

DEPARTMENT OF INDUSTRIAL MICROBIOLOGY

Ph. D COURSE WORK
In
MICROBIOLOGY

Name of the Program: PRE PhD COURSE in Microbiology

Program Objectives

- enhancing and imparting skills and knowledge in advance research methodologies of microbiology
- Solving the existing scientific problems in area of basic and applied microbiology
- Creating a highly skilled professionals with expertise in current trends of research in area of microbiology
- Imparting hand on experience to students of different techniques and instrumentations of advance biological/microbiological sciences
- Generating independent researchers who are capable of translating the research developed at laboratory scale to the industrial level.
- Imparting skills needed to become a successful academician, scientists or entrepreneur ¬ Inculcating the scientific ethics, temperament to contribute to field of science and help in nation building

Program Specific outcomes

The Students successfully completing the course will have following skills

- Solid basic knowledge of research methodologies in area of modern biological sciences specifically applied microbiology
- Contributing new methodologies and results in area of the basic and advanced microbiology for taking the research to next level
- Innovative scientists, skilled workforce to work in specialized area of microbiology
- Independent researchers who can contribute through fulfilling responsibility of academicians, scientist and entrepreneur
- Can start an independent research and can contribute in solving new problems faced in current science or in future.
- Develop As academicians in different university or colleges at national and international levels
- develop as a researcher at different research institute at national and international level where they can initiate their independent research
- Develop skill so that they can be absorbed by R& D sector of different biotechnological based company

Department of Industrial Microbiology

DDU Gorakhpur University, Gorakhpur

Faculty of Science

Course Work for Ph. D. Microbiology

Every student admitted in Microbiology for the Ph. D. programme will be required to pass a course work of minimum 21 credits. The division of this 21 credits course work is in three categories. Category-A (9 credits) courses are *compulsory* for all Ph. D. students of Microbiology. Category-B (6-credits) courses are *discipline-specific courses*. Category-C (6 credits) courses are *research theme- specific courses*.

Course Nature	Course Code	Core Courses	Credit
CATEGORY A(Compulsory Course)			
Compulsory Course (CORE)	MIC 601	Research Methodology	4+0
	MIC 602	Research and Publication Ethics	1+1
	MAT 603	Computer Fundamentals and IT	1+1
	MIC 604	Credit Seminar	0+1
			09 Credits
CATEGORY B :Elective Course (*Any two of the following*)			
Discipline-Specific Courses (for Microbiolgy students)	MIC 605	Molecular Microbiology	2+1
	MIC 606	Antimicrobial Compounds	2+1
	MIC 607	Infectious Diseases	2+1
	MIC 608	Microbial Enzyme Engineering	2+1
			06 Credits
CATEGORY C: Open Elective Course (*Any two of the following*)			
Research Theme-Specific Courses (open to other subject scholars)	MIC 609	Biofertilizer technology	2+1
	MIC 610	Food safety and Security	2+1
	MIC 611	Soil and agricultural microbiology	2+1
	MIC 612	Microbial Bioenergy	2+1
		Thesis	Non Credit
		Total	**21 Credits**

CATEGORY A: COURSE CONTENTS
(Compulsory Courses)

MIC 601:Research Methodology Credit: 3+1

- Microbiological media, types, Sampling technique, sterilization technique, various methods for isolation of pure culture methods for measurement of microbial growth, manipulation of environment, nutritional and genetic parameters, maintenance and preservation of microbes (pure culture). Basic staining techniques- Simple, Negative, Gram, Acid Fast.
- Chromatographic techniques – Gel filtration, ion exchange chromatography, hydrophobic interaction and reverse phase chromatography, affinity chromatography, gas chromatography, high performance liquid chromatography, fast protein liquid chromatography; Application in separation of proteins including enzymes.
- Microscopy- Bright field, Dark field, Fluorescence. Chromatography- gas chromatography, High performance liquid chromatography, Electrophoresis, SDSPAGE, isoelectric focusing. PCR, RAPD, RFLP- Differential and density gradient centrifugation. Separation of DNA/RNA using ultra centrifugation technique.Biochemical tests: Durham Tubes sugar fermentation, Methyl Red, VogesProskauer, Catalase, Oxidase, Nitrate reduction, Starch hydrolysis, Casein hydrolysis, Gelatin hydrolysis, Urea hydrolysis, Indole test, Citrate utilization, Phenylalanine deaminase, Decarboxylase, Litmus milk reaction
- Basics of Electrophoretic and centrifugation techniques –DNA and plasmid isolation, PCR, types and uses. Agarose Gelelectrophoresis technique, molecular markers.
- Quantitative methods; Principles and Designs of Experiments; Tools Parametric and Non~parametric statistics. Probability, Chi square test, t-test, Confidence interval, Errors. Levels of significance, Regression and Correlation coefficient. Analysis of variance for one way and two way classifications; Multiple Comparisons – Least Significant Difference Test, Duncan's New Multiple Range Test; Factorial Analysis; Analysis of Covariance.
- Scientific writing, types of citation, literature search, graphical abstracts, peer review. Research proposal and report writing, format and structure of research paper. Major research Institutes and funding agencies related to biological sciences.
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SUGGESTED READING:

1. Marder M P (2011) Research Methods for Science, Cambridge University Press

2. Rosner B (2010) Fundamentals of Biostatistics, 7th Edition, Brooks/Cole Cengage Learning Publication

3. Dunleavy P (2003) Authoring a PhD: How to Plan, Draft, Write and Finish a Doctoral Thesis or Dissertation. Palgrave Macmillan

4. Kothari, C.R.(2004). Research Methodology: Methods and Techniques, New Age International Publishers, New Delhi

5. Arya., P.P. and Pal, Y.(2001) Research Methodology in Management: Theory and case Studies. Deep and Deep Publishers Pvt. Ltd., New Delhi

Course Code: MIC 602: Research and Publication Ethics Credits: 1+1

Theory:-

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

2. Scientific conduct: Ethics with respect to science and research, Intellectual honesty and research integrity, scientific misconduct: Falsification, Fabrication and Plagiarism (FFP), Redundant publication: duplicate and overlapping publication, salami slicing, Selective reporting and misrepresentation of data.

3. Publication Ethics: definition, introduction and importance, best practices/ standard setting initiatives and guidelines: COPE, WAME, etc, conflict of interest, publication misconduct, definition concept, problems that lead to unethical behavior and vice-versa, types, Violation of publication Ethics, Authorship and contributor ship, identification of publication misconduct, complain and appeals, Predatory publisher and journals.

Practice:-

1. Open Access Publishing: open Access publication and initiatives, SHERPA/ RoMEO online resource to check publisher copyright and self-archiving policies, Software tool to identify predatory publication developed by SPPU, Journal finder/ journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester,etc.
2. Publication Misconduct: Group Discussion regarding subject specific Ethical Issues, FFP, Authorship, conflict of Interest, complaints and appeals: example and fraud from India and abroad.
3. Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools
4. Databases and Research Metrics: Databases: Indexing databases, Citation database: web of Science, Scopus etc. Research Metrics: Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite, Metrics: h-index, g-index, i10 index,altmetrics.

SUGGESTED READINGS

- P. Chaddah, (2018) Ethics in Competitive Research: Do not get scooped; do not get plagiarized, ISBN:978-9387480865
- Resnik, D. B. (2011). What is ethics in research & why is it important. National Institute of Environmental Health Sciences, 1-10. Retrived from http://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm
- Indian National Science Academy (INSA), Ethics in Science Education, Reasearch and Governance(2019),ISBN:978-81-939482-1-7. http://www.insaindia.res.in/pdf/Ethics_Book.pdf
- Bird, A. (2006)- Philosophy of Science.
- Maclntyre, Alasdair (1967)- A short History of Ethics.
- National Academy of Science, National Academy of Engineering and institute of Medicine (2009) On being a Scientist: A Guide of Responsible Conduct in Research.
- Beall, J. (2012) – Predatory publishers are corrupting open access. Nature, 489(7415).

Course Code: MAT 603: Computer Fundamentals and IT Credits: 02 (1+1)

Computer Basics: Definition, Characteristics of Computers, Evolution of Computer, Generations of Computer, Classification of Computers, Applications of Computers, Computer System and its Components, Computer Memory, Memory Capacity, Input and Output Devices, Software and Hardware, System Software and Application Software, Operating System Definition and Functions, Working with Windows, File Management in Windows, System Utilities in Windows.

Introduction of MS-Word: The screen and its elements, Creating new documents, Writing and Simple Formatting, Page layout, Table, Pictures and Graphics.

Introduction of MS-Excel and Power Point: Basics of MS-Excel, Perform calculation on data, Manage worksheet, Analyze alternative data sets, Create and Manage slides, Insert and Manage Simple Graphics, Add sound and movements of slides.

Introduction of Internet and email: How to create e-mail, E-mail- sending a message, E-mail- attaching a document, How to use internet in research work.

PRACTICE:

Working with MS-Word: Prepare a word document of Ph. D. Synopsis, Prepare word document of Research Paper, Prepare word document of References.

Working with MS-Excel and Power Point: Prepare Tables and Charts (Pi-chart, Bar-chart), Insert pictures in a worksheet, Prepare Power Point presentation of the Ph.D. Synopsis, Prepare power point presentation having animation graphics and sound.

Internet and e-mail: Creating e-mail in different ways and websites,How to search research papers in Google Scholar and any Journal, How to search information related to research.

Suggested Readings:

1. Introduction to Information Technology, ITL Education Solutions, Pearson Education.
2. Introduction to Computer Science, ITL Education Solutions, Pearson Education.
3. Computer Fundamentals by P.K.Sinha&Priti Sinha, BPB Publications.

Course code: MIC-604: Credit Seminar Credit: 0+1

The seminar paper will be related to the area of research of the candidate and the candidate should have to give a seminar presentation of it.

CATEGORY B: Discipline-Specific Courses (for Microbiology scholars)

MIC-605: MOLECULAR MICROBIOLOGY Credits: 2+1

Microbiology: Prokaryotic and eukaryotic cell structure, Microbial nutrition, growth and control, Sterilization. Microbial metabolism (aerobic and anaerobic respiration), Chemical basis of mutations and mutagens; plasmids, transformation, transduction, conjugation, Microbial diversity and characteristic features, Viruses. Genetics and life cycle of phages- lambda, T4, pi, Mu and Ml3. MicrobialGenomes.Microbial Genetics: Molecular structure of genes and chromosomes, DNA replication and control; Transcription and its control; Translational processes; Regulatory controls in prokaryotes; Gene interaction; Complementation; Linkage, recombination and chromosome mapping; Extrachromosomal inheritance; Chromosomal variation; Transposable elements.Gene transfer in Bacteria - Modes of gene transfer and genetic analysis, phages, and yeast molecular genetics, genetic and physical mapping of bacteria.

Suggested Readings:

1. Prescott - Harley - Klein - Microbiology - VII Edition - International edition - 2007 - McGraw Hill - ISBN-10:0072992913
2. Voet. D. and Voet. J. G. - 1995 - Biochemistry - II Edition - John Wiley and Sons, Inc
3. Microbial Genomes - D. A. Realman and E. Strauss - 2000 - American Academy OfMicrobiology
4. Practical handbook of microbiology- II Edition- Emanuel Goldman and Lorrence H. Green.2008

MIC-606: Antimicrobial Compounds Credits: 2+1

Antimicrobial resistance: An overview of the history and development of antimicrobials, Introduction and impact of antimicrobial resistance, Antimicrobial agents-Antibiotics, Anti-fungal, Anti-viral, antiprotozoan; Antibiotic classification and mechanisms of their action, Evolution and molecular mechanisms of antimicrobial resistance, multi-drug resistance, superbugs, Global emergence of antimicrobial resistance, Factors contributing the emergence of antimicrobial resistance Antimicrobial susceptibility testing, Preventive and control strategies to control antimicrobial resistance, One Health approach. New methods for antimicrobials: Antimicrobial Discovery and Developments: Antimicrobials and their usage in human medicine, veterinary, and plant/animal agriculture. Biochemistry and molecular genetics of Antimicrobial resistance, Requirements to novel antimicrobial or alternatives, antibiotic resistance breakers or antibiotic adjuvants, antimicrobial peptides, drug-repurposing, natural products as a source for novel antimicrobials, Screening and development approaches for new microbial natural product, High-content screening methods, antimicrobial in-vitro and in-vivo screening Assays

Suggested reading

1.Stefan Schwarz &Lina Maria Cavaco, Jianzhong Shen (2018). Antimicrobial Resistance in Bacteria from Livestock and Companion Animals, ASM Press

2. Scott H. Podolsky (2015) The Antibiotic Era: Reform, Resistance, and the Pursuit of a Rational Therapeutics, Johns Hopkins University Press

3. Susan L. Prescott & Alan C. Logan (2017). The Secret Life of Your Microbiome: Why Nature and Biodiversity are Essential to Health and Happiness,New Society Publishers

MIC-607: Infectious Diseases **Credits: 2+1**

Major classes of human pathogens, Inoculum, Sources of infectious human pathogens, pathogen transmission and dissemination . Types of Infectious Human Diseases. Emerging diseases: Disease outbreaks, integrated disease surveillance program by National Centre for disease control, Biology of Emerging Diseases: Ebola, Swine Flu, SARS, Plague, Dengue, Zika, Chikungunya; CDC outbreak list, IDSP weekly outbreak mapping by NCDC.

AMR and Epidemiology: Anti-microbial resistance, Case studies on Tuberculosis with emergence of MDR, XDR and TDR TB. Case study on Salmonella and E. coli O157:H7. Epidemiology and epidemiology research: current perspectives. Diverse approaches for tackling AMR, Host directed therapies, WHO Emergencies preparedness and response mechanism.

Suggested Reading

1.Emerging Infectious Diseases: A Guide to Diseases, Causative Agents, and surveillance; By Lisa A. Beltz, Wiley Publication.

2. Cell Press Reviews: Cancer Therapeutics, Cell press 2013

3. Novel Designs of Early Phase Trials for Cancer TherapeuticsbyShivaani Kumar and Chris Takimoto

MIC-608: Microbial Enzyme Engineering **Credits: 2+1**

Batch, fed-batch and continuous cultivation, sterile operations, design of experiment for bioprocess optimization, industrial synthetic biology, high throughput bioprocess design, bioseparation and downstream processing-membrane separation techniques, chromatographic separation techniques, water purification etc., interactions and integration of microorganisms, bioreactor and downstream processing. Development of reactors and processes for stabilization of organic and industrial wastes, miniaturisation of bioreaction systems, miniplant technology for integration of biosynthesis and downstream processing. Industrial enzymes, kinetics of enzyme reactions, biochemical characterization of enzymes, graphical analysis of kinetic data, pH and temperature dependence, development of recombinant clones for overproduction of enzymes and metabolites. Enzyme engineering and design: substitution, insertion, hybrid proteins, genes for novel enzymes.directed evolution and site directed mutagenesis approaches to improve industrial enzymes. development of bio-sensors for detection of various analytes, development of cell culture techniques for cultivation of plant and animal cells in specialized reactors for production of therapeutic compounds.

Suggested reading

1. Yoo YJ et al (2017) Fundamentals of Enzyme Engineering, Springer
2. Stanbury et al (2003) Principle of Fermentation technology, Butterworth-Heinemann

CATEGORY C: Research Theme- Specific Courses (open for other subject scholars)

MIC-609: BIOFERTILZER TECHNOLOGY **Credits: 2+1**

Biofertilizers: Definition and types, importance of biofertlizers in agriculture. Characteristics of biofertilizers: *Rhizobium, Azotobactor, Azospirillum*, Phosphate-solubilizing microorganisms, cyanobacteria, *Azolla,* Mycorrhizae. Symbiosis: Physiology, biochemistry and molecular genetics of symbiosis. Enzymes and their regulation: Nitrogenase,hydrogenase. Production technology: Strain selection, sterilization, growth and fermentation, mass production of variousbiofertilizers. Application technology: Standards and quality control, application for field and tree crops, nursery plants andseedlings .Extension, promotion and marketing: Extension strategies, diagnosis for the effectiveness of inoculation, improvement in distribution system. Commercialization and regulation.

Suggested Readings:

1. J.R. Gallon and A.E. Chaplin, 1987. An Introduction to Nitrogen fixation, Cassel Educational Limited,London
2. A.N. Rai, 1990. A Handbook of Symbiotic Cyanobacteria. CRC Press, Boca Raton, Florida,USA.
3. J.R. Postgate, 1987. Nitrogen Fixation, second edition. Arnold, London.
4. G. Stacey, R.H. Burris and H.J. Evans, 1992. Biological Nitrogen Fixation. Chapman &Hall.
5. J.I. Sprent and P. Sprent, 1990. Nitrogen Fixing Organisms: Pure and Applied Aspects. Chapman &Hall,London
6. S. Kannaiyan, K. Kumar and K Govindrajan, 2007. Biofertlizers Technology. Saujanya Books, NewDelhi.
7. N.S. Subbarao, 1997. Biofertlizers in Agriculture and Forestry. Indian Book House Limited, NewDelhi
8. P.A. Roger and Kulasooriya, 1980. Blue-green Algae and Rice. The International Rice Research Institute, Manila,Philipines.

MIC-610: FOOD SAFETY AND SECURITY **Credits: 2+1**

Microbiology of food of animal and plant origin. Food spoilage, Causes, Biochemical types of spoilage and Microorganisms involved. Major Foodborne diseases, Biological, chemical, and physical hazards of food, Microbiological testing of food. Bacterial toxins related to food borne illness, Mycotoxins. Hazard analysis and critical control points (HACCP), Agricultural and animal food production and manufacturing practices, Food legislation and standards, ISO 22000, Food and Drug Administration (FDA), Food Safety and Standards Authority of India (FSSAI), Basic concept & issues food security, genetically modified foods, climate change and food security, Nutrition and food security, Nutrition and infectious/non-communicable diseases.

Major methods of food preservation: physical methods, chemical methodsand packaging techniques. Types of preservative classes, Controlled Atmosphere and Modified packaging .

Suggested Reading

. Ian C. Shaw (2012).Food Safety: The Science of Keeping Food Safe, Wiley-Blackwell

Hal Kin (2013) Food Safety Management: Implementing a Food Safety Program in a Food Retail Business, Springer

Lewis H Ziska (2017). Agriculture, Climate Change and Food Security in the 21st Century Our Daily Bread, Cambridge Scholars Publishing.

MIC-611: SOIL AND AGRICULTURAL MICROBIOLOGY **Credits: 2+1**

Introduction to soil microorganisms – bacteria (cyanobacteria and actinobacteria), algae, fungi, protozoans, nematodes and viruses –Role of microbes in soil fertility.Microbial associations in phytosphere: rhizosphere – phyllosphere – spermosphere. Role of Microbes in different Biogeochemical cycles. Bioremediation and Bioleaching. Mycorrhiza – types and importance to agriculture – organic matter decomposition – humus formation.
Biochemistry of nitrogen fixation.Biofertilizers – definition, importance – types and their application methods –Mass production of blue green algae, Azolla and mycorrhiza. Plant response to biofertilizers application. Plant growth promoting rhizobacteria – Biological control of phytopathogens – Mechanism of control – Trichoderma sp. and Pseudomonas fluorescens as biocontrol agents – Disease suppressive soils – Biopesticide and their importance: Bacterial, fungal and viral.

Suggested reading

Sylvia D.M., Fuhrmann, J.J., Hartel P.J. and Zuberer D.A. (2005) Principles and Applications of Soil Microbiology, 2nd Edn. Pearson, Prentice Hall.

Subba Rao N.S. (2001) Soil Microorganisms and plant growth, Oxford and IBH Publishing Co. Pvt. Ltd.

Glick B.R. (2015) Beneficial Plant Bacterial Interactions, Springer.

Paul E.A. (Ed.) (2015) Soil Microbiology, Ecology and Biochemistry, 4th Edn, Academic Press.

Madigan M.T., Bender K.S., Buckley D.H., Sattley W.M. and Stahl D.A. (2017) Brock Biology of Microorganisms, 15th Edn. (Global Edn.) Pearson Education.

MIC-612: MICROBIAL BIOENERGY Credits: 2+1

Need for alternative fuel sources - History of biofuels - Global scenario of biofuel production - Microbial macromolecules as biofuel feedstocks - Bioalcohol - Biodiesel Biohydrogen - Biomethane -Biokerosine -Biochar (Bio - oil, syngas) - Microbial fuel cells. Microbial Biofuels Introduction - Importance - Merit and demerits - Possibilities and opportunities. Microbial feedstocks for biofuels - Microalgae Cyanobacteria - Diatom - Bacteria - Fungi. Biomass production - Raceway ponds - Photobioreactors (thin film & tubular) - Fermenters. Bioconversion of feedstocks - Saccharification - ABE fermentation - Transesterification - Pyrolysis - Fischer-Tropsch process. Microbial biorefinery. Metabolic engineering for biofuel production Acet'OrbirCarEiolaSe (ACCase) - Butanol dehydrogenase (AdhE2) - Function and role in biofuel synthesis pathways. Metabolic engineering of microalgae for biofuel production - pBUT1 and pBUT2 plasmids for targeted gene expression. Insilico approaches - KEGG.

SUGGESTED READINGS:

- Deepak Y, Khare PK, Gupta RK, Paliwal GS (2013). Microbial Biotechnology andEcology. Daya Publishing House. https://www.elsevier.com/books/biotechnology-of-microbial.../978-0-12-803725-6
- Nuzhat Ahmed, Fouad M. Qureshi, Obaid and Y. Khan. (2001) Industrial andEnvironmental Biotechnology, Publisher: Horizon Scientific PressEditors: England Horizon scientific press
- Patra JK, Vishnuprasad, Chethala N, and Das G (2018). MicrobialBiotehnology:Volume 1:Appication in Agriculture and Environmetal –JayantaKumar. Microbial Biotechnology: Energy and Environment By Rajesh Arora
- Peter J (1995) World Journal of Microbiology and Biotechnology,Publisher: Microbiological Resources Centres (MIRCEN); UNESCO; InternationalUnion of Microbiological Societies (IUMS), Springer Verlag.
- V K Mutha. (2010). Handbook of Bioenergy and biofuels. SBS Publishers
- Vijai G and Susana RC (2017). New and Future Developments in MicrobialBiotechnology and Bioengineering by Elsevier