National Education Policy-2020
Common Minimum Syllabus for all U.P. State Universities/ Colleges
SUBJECT: INDUSTRIAL MICROBIOLOGY

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Syllabus Developed by:

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Department of Higher Education
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National Education Policy-2020
Common Minimum Syllabus for all U.P. State Universities

Proposed Titles for Theory and Practical Papers
Under Graduate Programme

SUBJECT: INDUSTRIAL MICROBIOLOGY

Syllabus Developed by:

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Department of Higher Education, Government of Uttar Pradesh, Lucknow

National Education Policy-2020

Common minimum syllabus for U.P. State Universities

Certificate Course in Industrial Microbiology, Diploma in Industrial Microbiology and B.Sc. Industrial Microbiology

Semester wise titles of the papers for B.Sc. (Industrial Microbiology)

Year	Semester	Course Code	Paper Title	Theory /Practical	Credits
1	I	B017101T	Fundamentals of Industrial Microbiology	Theory	04
		B017102P	Basic Techniques in Microbiology	Practical	02
	II	B017201T	Biochemistry & Microbial Physiology	Theory	04
		B017202P	Biochemical & Physiology lab.	Practical	02
2	III	B017301T	Fermentation Technology	Theory	04
		B017302P	Fermentation Technology Practical	Practical	02
	IV	B017401T	Environmental & Agricultural Microbiology	Theory	04
		B017402P	Environmental & Agricultural Microbiology Lab	Practical	02
3	V	B017501T	Industrial Food Microbiology	Theory	04
		B017502T	Immunology & Medical Microbiology	Theory	04
		B017503P	Experiments in Food and Immunology & Medical microbiology	Practical	02
	VI	B017601T	Molecular Biology and Microbial Genetics	Theory	04
		B017602T	Computers, Bioinformatics and Biostatistics	Theory	04
		B017603P	Molecular Biology and Bioinformatics Lab	Practical	02

One year Course will lead to “Certificate Course in “Industrial Microbiology”

Two years Course will lead to “Diploma in Industrial Microbiology”

Three Years Course will lead to “Degree Industrial Microbiology”

Proposed Year wise Structure of UG Program in Industrial Microbiology

Programme/ Year	Sem.	Course code	Paper title	Credits	Teaching hours
1 **Certificate Course in Industrial Microbiology**	I	B017101T	Fundamentals of Industrial Microbiology	4	60
		B017102P	Basic Techniques in Microbiology	2	60
	II	B017201T	Biochemistry & Microbial Physiology	4	60
		B017202P	Biochemical & Physiology lab.	2	60
2 **Diploma in Industrial Microbiology**	III	B017301T	Fermentation Technology	4	60
		B017302P	Fermentation Technology Practical	2	60
	IV	B017401T	Environmental & Agricultural Microbiology	4	60
		B017402P	Environmental & Agricultural Microbiology Lab	2	60
3 **Degree in Bachelor of Science**	V	B017501T	Industrial Food Microbiology	4	60
		B017502T	Immunology & Medical Microbiology	4	60
		B017503P	Experiments in Food and Immunology & Medical microbiology	2	60
	VI	B017601T	Molecular Biology and Microbial Genetics	4	60
		B017602T	Computers, Bioinformatics and Biostatistics	4	60
		B017603P	Molecular Biology and Bioinformatics Lab	2	60

Subject prerequisite

To study INDUSTRIAL MICROBIOLOGY at undergraduate, a student must have Biology in Class 12.

Programme Objectives (POs)

1. The programme has been designed in such a way so that the students get exposed to strong theoretical and practical background on various domains of Industrial Microbiology.
2. The programme includes details of important microorganisms of agricultural, food and industrial importance, biomolecules, tools and techniques, enzymes, immunology, cell biology, molecular biology & microbial genetics to make the study of industrial microbiology for sustainable development of human society.
3. The practical courses have been designed to equip the students with the laboratory skills in basic microbiology. Students will able to design and conduct experiments, as well as to analyze and interpret scientific data.
4. The programme will provide students with the knowledge and skill base that would enable them to undertake further studies in microbiology/industrial microbiology and related areas or in multidisciplinary areas that involve microbiology, biochemistry, biotechnology and molecular biology and help develop a range of generic skills that are relevant in enhancing entrepreneurship skills among students
5. The students will be exposed to a wide range of careers that combine microbiology, environment, industry and medical.

Certificate Course in Industrial Microbiology	
B. Sc. I Programme Specific Outcomes (PSOs)	
PSO1	Students will be able to acquire, articulate, retain, and apply specialized skills and knowledge relevant to basics of industrial microbiology.
PSO2	Students will be able to appreciate the diversity of microorganisms and microbial communities inhabiting a multitude of habitats, understand their industrial significance to man and nature.
PSO3	Students will acquire and demonstrate proficiency in good laboratory practices in a microbiological laboratory and be able to explain the theoretical basis and practical skills of the tools and techniques commonly used to study industrial microbiology.
PSO4	Students will gain fundamental knowledge about the biochemistry and microbial physiology.
PSO5	The certificate course will enable students to apply for technical positions in government and private labs/institutes.

Diploma Course in Industrial Microbiology	
B.Sc. II Programme based outcomes	
PSO 1	Students will develop familiarity and understanding of the concepts of fermentation technology.

PSO 2	Students will develop knowledge about various types of fermenters used in laboratory and industries. They will learn the processing and quality control of fermentation products.
PSO3	Students will be adequately capable to utilize techniques involved in food preservation. They will also be able to describe that how microorganisms microorganisms can be used as pesticides,
PSO4	The students will learn about the microorganisms having impact on environment and agriculture.
PSO5	Students will be able to work in a variety of fields, including higher education institutions, public health, environmental organizations, and the food, dairy, pharmaceutical, fermentation, distillery and biotechnology industries.

Bachelor of Science in Industrial Microbiology	
B.Sc. III Programme Specific Outcomes (PSOs)	
PSO1	Students of B.Sc. Industrial Microbiology Programme will learn to use scientific logic as they investigate a broad variety of contemporary subjects covering different areas of basic microbiology such as Biochemistry, Microbial Physiology, Bacteriology, Virology, Food Microbiology, Fermentation Technology, Immunology, Cell Biology, Molecular Biology, Genetics, Immunology, and Microbial Genetics, importance of agricultural and environmental microbiology.
PSO2	Students will learn about various biotechnological applications of microorganisms as well as industrially relevant substances developed by microorganisms. They will learn about the special role microbes play in genetic modification technologies.
PSO3	Students will learn and develop good laboratory practices in a microbiological laboratory, as well as be able to explain the theoretical foundations and practical skills of the tools and technologies widely used in this area. Students can gain proficiency in the quantitative skills needed to analyze biological problems.
PSO4	Students will learn about experimental methods, hypothesis creation and testing, and experiment design and execution. Students can develop their critical thinking skills as well as their ability to read and interpret scientific literature. Via successful presentation of experimental findings as well as workshops, students can acquire good oral and written communication skills.
PSO5	The Degree courses will enable students to go for higher studies in Industrial Microbiology and Allied subjects leading to Post Graduation and Ph.D. degrees.

Detail Syllabus of

B.Sc. I Year

or

Certificate in Industrial Microbiology

Programme/Class: Certificate	**Year: First**	**Semester: First**
Subject: Industrial Microbiology		
Course Code: B017101T	**Course Title:** Fundamentals of Industrial Microbiology	

Course Learning Outcomes:

Upon successful completion of the course, the student will:

1. Be acquainted with the historical account and development of microbiology as a scientific discipline.
2. Have gained knowledge on different systems of classification. They will also acquire an overview of acelluar and cellular microorganisms.
3. Have acquired in-depth knowledge of the diversity, distribution, cell structure, life cycles and economic importance of bacteria, archaea, fungi, viruses, protozoa and algae.
4. Learn and gain skills of isolation, culturing and maintenance of pure culture.
5. Gain knowledge about application of bio-instruments.
6. Have a broad perspective of the scope of industrial microbiology.

Credits:4	**Core:** Compulsory
Max. Marks: 25+75	**Min. Passing marks:** as per rules

Total No. of Lectures-Tutorials-Practical(in hours per week):**L-T-P:**4-0-0

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**History of Industrial Microbiology** Introduction, scope and historical development of industrial microbiology (discovery era, transition period, golden age and microbiology in the 21st century), Applied branches of microbiology and industrial importance of various microorganisms of industrial importance.	6
II	**Microbial Diversity** Diversity of Microbial World, Prokaryotic cell, Structure of Bacterial cell, Archaebacteria and Eubacteria, Structure and function of Plasma membrane, cell wall, capsule, endospore, flagella, nucleod, plasmid, Gram positive and Gram negative bacteria, chromosomal & extra chromosomal genetic material and cell inclusions.	10
III	**Study of Fungi, Algae, Protozoans and viruses** Characteristics of Fungi, Algae, Protozoans, Viruses. Principles of classification of bacteria, algae, fungi, protozoa, viruses.	10
IV	**Methods for studying microorganisms** Culture media: preparation and types of defined, differential, selective and enrichment culture, Isolation techniques: Pour plate, spread plate, streak plate. Preservation and maintenance of culture Methods of sterilization: physical and chemical, media types, Isolation and maintenance of pure cultures of microorganisms, and preservation techniques.	9
V	**Microbial growth** Microbial growth, phases of growth, conditions of growth, measurement of growth, bacterial sporulation and germination, binary fission.	7
VI	**Microscopy** Microscopy Light, phase contrast, electron, scanning and transmission electron microscopy, staining techniques for light microscopy, sample preparation for electron microscopy	5

VII	**Equipments used in Microbiology** autoclave, oven, laminar air flow, centrifuge, colorimetry and spectrophotometry, Electrophoretic techniques for proteins and nucleic acids, PCR	8
VIII	**Microbial identification** Techniques used for identification of microorganisms biotyping, serotyping, molecular techniques.	5

Suggested Readings:

1. Aneja,K.R. *et al*.: A Text book of Basic and Applied Microbiology. New Age International Publishers, New Delhi.
2. Patel, A.H.: Industrial Microbiology, McMillan India.
3. Tauro, Yadav & Kapoor : Microbiology, New Age International Publishers, New Delhi.
4. Baveja C.P., Textbook of microbiology APC 6th edition.
5. Dubey R.C.. and Maheshwari D.K., Textbook of microbiology, S Chand Publications.
6. Pelczar M.J., Chan E.C.S and Kreig N.R., Microbiology, Mcgraw-Hill Book Company, New York.
7. Prescott Lansing M., Harley John P. and Klein Donald A., Microbiology, WCB Mcgraw- Hill, New York.
8. Sharma P.D., Microbiology, Rastogi Publications.
9. **Suggested digital platform links:**
    - https://vlab.amrita.edu/?sub=3&rch=73
    - https://www.mcgill.ca/microimm/undergraduate-programs/courses
    - https://www.youtube.com/watch?v=8IJRzcPC9wg
    - https://instruct.uwo.ca/biology/090b/1290b%201-7.pdf
    - https://courses.lumenlearning.com/boundless-microbiology/chapter/methods-of-classifying-and-identifying-microorganisms/
    - https://www1.udel.edu/biology/Wags/histopage/illuspage/lec1/lec1.htm

Course prerequisites: To study this course, a student must have had the subject biology in 12th.

Suggested Continuous Evaluation Methods:

House Examination/Test:10 marks

Written Assignment/Presentation/Project/Research Orientation/Term papers/Seminar: 10 Marks

Class performance/ Participate: 5Marks

Further Suggestions: None

Programme/ Class: Certificate	**Year: First**	**Semester: First**
Subject: Industrial Microbiology		
Course Code: B017102P	**Course Title:** Basic Techniques in Microbiology	

Course Learning Outcomes:

After completing the course, the student will be able:

1. To understand the instruments, microbial techniques and good lab practices for working in a microbiology laboratory.
2. Practical skills in the laboratory experiments in microbiology.
3. Develop skills for identifying microbes and using them for industrial, agricultural and environmental purpose.
4. To prepare slides and stain to see the microbial cell.

Credits:2	**Core:** Compulsory
Max. Marks: 25+75	**Min. Passing marks:** as per rules

Total No. of Lectures-Tutorials-Practical(in hours per week):**L-T-P:**0-0-2

S. No.	**Topics**	**Total No. of Lectures/ Hours (60)**
1.	Microbiology good laboratory practices and biosafety. Neutralization and cleaning of glassware. Measurement of microorganisms (Micrometry).	12
2.	To study the principle of and application of important instruments – Autoclave, Incubator, BOD Incubator, Hot Air Oven, pH Meter, spectrophotometer, Colony Counter, Centrifuge Machine and Laminar Air Flow.	12
3.	Preparation of different culture media- nutrient agar/nutrient broth for bacterial culture, PDA for fungal culture. Enumeration of colony forming unit (CFU) of microorganisms by spread plate and pour plate techniques. Isolation of pure culture of bacteria by streak-plate method.	12
4.	Staining of bacteria- Simple staining- methylene blue, Gram's staining, Acid fast staining, Ziehl Neelsen staining, Giemsa staining, Structural staining- capsule, endospore. Staining of fungi using lactophenol and cotton blue (*Rhizopus, Mucor, Aspergillus, Penicillium*).	12
5.	Sterilization of culture media using autoclave and assessment for sterility. Sterilization of glassware using hot air oven. Sterilization of heat sensitive material by membrane filtration and assessment for sterility. Demonstration of the presence of microorganisms in the environment by exposing nutrient agar plate to air.	12

Suggested readings:

1. Microbial Technology. Vol I- Microbial processes and Vol II – Fermentation technology edited by H.J. Peppler and D. Perlman, 2nd edition. Academic Press, USA, 2009.
2. James G Cappucino and Natalie Sherman, Microbiology: A laboratory manual. 6th edition, Published by Pearson education. 2004.
3. Rajan S and Selvi Christy. Experimental procedures in life sciences. Anjana Book House, publishers and distributors, Chennai. 2011.
4. Kannan N, Handbook of laboratory culture media, Reagents, Stains and buffers. Panima Publishing Corporation, New Delhi.2003.
5. **Virtual lab links:**
   - https://www.vocareum.com/home/programming-lab/?gclid=Cj0KCQjw16KFBhCgARIsALB0g8Jq0cYFFf3iJGAUACz-SZCbHd_NmJphEQzg9roGP84-TN_ilqPc69oaAlJYEALw_wcB
   - https://www.labster.com/microbiology-virtual-labs/
   - https://www.scienceprofonline.com/virtual-micro-main.html

Programme/Class: Certificate	**Year: First**	**Semester: Second**
Subject: Industrial Microbiology		
CourseCode: B017201T	**Course Title:** Biochemistry & Microbial Physiology	

Course Learning Outcomes:

Upon successful completion of the course, the student:

1. Will be able to apply the fundamental concepts of bioenergetics, pH, pKa, and the buffer system to biological systems.
2. Will understand the structure of carbohydrates, lipids, proteins, and nucleic acids.
3. Will understand the fundamental principles of enzyme biochemistry, enzyme kinetics, and be aware of the various enzyme variants present in living cells.
4. Will be familiar with a variety of microbial transport systems.
5. Will have a thorough understanding of bacterial growth patterns, bacterial growth curves, generation time and basic growth rate calculations, and the impact of the environment on growth.
6. Understand how bacteria use biochemical pathways for energy production and storage during glucose growth in aerobic and anaerobic environments.
7. Understand how interactions between microbes and the environment influence cellular physiology and be familiar with the photosynthesis mechanisms of various bacteria.

Credits:4	**Core:** Compulsory
Max. Marks: 25+75	**Min. Passing marks:** as per rules

Total No. of Lectures-Tutorials-Practical(in hours per week):**L-T-P:**4-0-0

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Biochemistry of Microbes** Bioenergetics basics, Chemical composition of cell, molecules of living systems, pH and pK, Buffers.	4
II	**Carbohydrates** Structure & classification of carbohydrates-monosaccharides, disaccharides, polysaccharides, storage and structural pilysaccharides; Carbohydrate metabolism pathways- EMP pathway, Pentose phosphate pathway (PPP), TCA Cycle, Electron transport chain (ETC), Gluconeogenesis	10

III	**Proteins** Amino acids, general formula and concept of zwitterion; Protein structure: primary, secondary- peptide unit salient features, α helix, β sheet, β turn, tertiary and quaternary structures of proteins, Protein folding	8
IV	**Lipids & Nucleic acids** Structure and classification of lipids- Fatty acids structure and functions; Saponification Structural lipids; Phosphoglycerides; Sphingolipids; Metabolism of lipids- Alpha and beta oxidation of lipids; Nucleic acids Structures, Double helical structure of DNA. Types of DNA: A, B, Z. Physic-chemical properties of DNA. RNA types-rRNA, mRNA, tRNA.	8
V	**Enzymology concepts** Enzymes and their classification, Enzyme kinetics, allosteric enzymes, Michaelis- Menten equation, coenzyme, isozyme, enzyme inhibition and regulation	6
VI	**Transport of solutes and nutrients** Nutrient uptake mechanisms-passive and facilitated diffusion; Primary and secondary active transport; Concept of uniport, symport, antiport, group translocation; Iron uptake	8
VII	**Photosynthetic microbes** Oxygenic photosynthetic bacteria- PSI and PSII, Z-scheme, Non- cyclic photophosphorylation; Anoxygenic photosynthetic bacteria- Cyclic photophosphorylation. Photosynthesis of Purple and Filamentous green bacteria, Cyanobacteria and Green sulphur bacteria. Calvin cycle.	8
VIII	**Microbial growth kinetics** Bacterial growth curve, Generation time and specific growth rate; Growth kinetics in Batch, Fed batch and continuous cultures.	8

Suggested Readings:

1. Gilbert H.F. 2000. *Basic concepts in biochemistry: A student's survival guide*. Second Edition. Mc-Graw-Hill Companies, health professions Division, New York.
2. Madigan M.T., Martinko J.M., Stahl D.A. and Calrk D.P. 2012. *Brock Biology of Microorganisms*. 13th ed. Pearson Education Inc.
3. Moat A.G., Foster J.W. and Spector M.P. 2002. *Microbial Physiology*, 4th edition. A Johan Wiley and sons inc., publication.
4. Kim B.H. and Gadd G.M. 2008. *Bacterial physiology and metabolism*. Cambridge University Press, Cambridge.
5. Jeremy M. Berg, John L. Tymoczko, Gregory J. Gatto Jr., Lubert Stryer.2015. Biochemistry 8th edition. W. H. Freeman.
6. **Suggested digital platform links:**
   - https://ocw.mit.edu/courses/biology/7-343-photosynthesis-life-from-light-fall-2006/lecture-notes/
   - https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/photosynthetic-bacteria
   - https://open.oregonstate.education/generalmicrobiology/chapter/microbial-growth/
   - https://bio.libretexts.org/Bookshelves/Microbiology/Book%3A_Microbiology_(Bruslind)/11%3A_Microbial_Nutrition
   - https://www.nature.com/scitable/content/the-composition-of-a-bacterial-cell-14705043/

Course prerequisites: To study this course, a student must have had the subject **Fundamentals of Industrial Microbiology** in I Semester.

Suggested Continuous Evaluation Methods:
House Examination/Test:10 marks
Written Assignment/Presentation/Project/Research Orientation/Term papers/Seminar: 10 Marks
Class performance/Participate: 5Marks
Further Suggestions: None

Programme/Class: Certificate	**Year: First**	**Semester: Second**
Subject: Industrial Microbiology		
CourseCode: B017202P	**Course Title: B**iochemistry & Physiology lab.	

Course Learning Outcomes:

After completing the course, the student will be able to:

1. Understand the structures and properties of carbohydrates, as well as how to perform chemical tests to identify their presence in samples.
2. Will have learned how to use a spectrophotometer and will have gained practical knowledge of biochemical methods for proteins.
3. Will be able to perform titrations and calculate the iodine number, which is the degree of lipid saturation or unsaturation.
4. Will have a detailed understanding of bacterial growth patterns, bacterial growth curves, generation time and basic growth rate estimates, as well as the influence of the environment on bacterial growth.

Credits:2	**Core:** Compulsory
Max. Marks: 25+75	**Min. Passing marks:** as per rules

Total No. of Lectures-Tutorials-Practical(in hours per week):**L-T-P:**0-0-2

S. No.	**Topics**	**Total No. of Lectures/ Hours (60)**
1.	Concept of pH and buffers, preparation of buffers and Numerical problems to explain the concepts, Preparation of stock and working solutions, Handling of pipettes and micropipettes	4
2.	Qualitative/Quantitative tests for Carbohydrates: Fehling's Test, Benedict's Test, Iodine Test) Quantitative estimation of carbohydrate by DNSA method.	14
3.	Qualitative/Quantitative tests for Amino acids and Proteins: Ninhydrin test, Biuret test, Lowry test. Quantitative estimation of proteins by Lowry's method	14
4.	Qualitative/Quantitative tests for lipids**:** Solubility Test, Translucent Spot Test, Emulsification Test, Saponification Test, Tests for the Free Fatty Acids, Unsaturation Test, Burchard Test Determination of Iodine Number	14
5.	Study and plot the growth curve of E. coli by turbidometric method.	10
6.	Calculations of generation time and specific growth rate of bacteria from the graph plotted with the given data.	2
7.	Study of protein secondary and tertiary structures with the help of models	2

Suggested readings:

1. S. K. Sawhney, Randhir Singh, Introductory Practical Biochemistry, 2000, Narosa.
2. Sambrook J and Russell DW., Molecular Cloning: A Laboratory Manual. 4th Edition, 2004, Cold Spring Harbour Laboratory press.
3. Daniel M. Bollag, Stuart J. Edelstein, Protein Methods, Volume 1, 1991, Wiley.
4. Maloy SR, Cronan JE and Friefelder D, Microbial Genetics 2nd EDITION., 2004, Jones and Barlett Publishers
5. Larry Snyder. Molecular Genetics of Bacteria: 3rd (third) Edition.
6. **Virtual lab links:**
    - https://pubs.acs.org/doi/pdf/10.1021/ed065p548
    - http://amrita.olabs.edu.in/?sub=73&brch=3&sim=119&cnt=2
    - https://fac.ksu.edu.sa/sites/default/files/bch202_practical-modefiedff-converted.pdf
    - https://www.cdrfoodlab.com/solutions/fats-oils/
    - https://www.ausetute.com.au/redsugar.html

Detail Syllabus of

B.Sc. II Year

or

Diploma in Industrial Microbiology

Programme/Class: Diploma	Year: Second	Semester: Third
Subject: Industrial Microbiology		
Course Code: B017301T	Course Title: Fermentation Technology	

Course Learning Outcomes:

Upon successful completion of the course, the student:

1. Understand role of microorganism in industry
2. Develop understanding about fermentation processes in industry
3. Know about Processing & selection of best microbial strains for the industry
4. Gain fundamental knowledge of fermentator design and function
5. Gain knowledge about production of various pharmaceutical products or industrially important product

Credits:4	Core: Compulsory
Max. Marks: 25+75	Min. Passing marks: as per rules

TotalNo.ofLectures-Tutorials-Practical(inhoursperweek):**L-T-P:**4-0-0

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Introduction** Fermentation processes, Microbial culture selection for fermentation processes. Media formulation and optimization; inoculum development; strain improvement	8
II	**Microbial growth** Microbial growth kinetics in Batch, fed batch and continuous cultures	6
II	**Design of fermenters** Design and operation of Fermenters, Basic concepts for selection of a reactor, Packed bed reactor, Fluidized bed reactor, Trickle bed reactor, Bubble column reactor, Scale up of Bioreactor.	8
III	**Processes involved in fermentation-I** Scale-up process and Scale down process: Purposes of scale-up; Stages of fermentation –laboratory scale, pilot-plant scale and production scale; Criteria of scale-up for critical parameters-aeration, agitation, broth rheology and sterilization; Scale-down	7
IV	**Processes involved in fermentation-II** Cell disruption; Filtration; Centrifugation; Liquid-liquid extraction; Solvent extraction (distillation); Chromatography; Electrophoresis; Lyophilization	6
V	**Quality control & quality assurance test** QC in fermentation processes: Principles of validation for pharmaceutical industry; QA Tests of finished product-Sterility testing, Pyrogen testing, Ames test and modified Ames test, toxicity testing, Shelf life testing	7
VI	**Food preservation methods** High temperatures, drying, food additives and radiation. Preservation of milk, meat, fish, fruits and vegetables; Food hygiene maintenance	4
VII	**Fermentation products** Large scale fermentaion of acetone, butanol and ethanol (ABE) and alcoholic Beverages -Beer and Wines; Vitamins -B12 and Riboflavin; Antibiotics-Penicillin and Streptomycin); Organic acids-Citric acid, Acetic acid and Lactic acid; Amino acid-	8

	Glutamic acid; Enzymes-Amylase, Lipases, Esterases and Restriction enzymes; Vaccines –Tetanus, Polio and Rabies.	
VIII	**Biomass based products** Biopesticides- Thuricide and Trichoderma; Yeast: SCP, Baker's and Distiller's yeast; Milk products: Cheese and Yogurt; Microbial transformation products: Steroids	6

Suggested Readings:

1. Biely, J.E. and Ollis, D.F. Bio Chemical Engineering Fundamentals (1986), Mcgraw Hills. Rehm, H.J. and Reed, G. (ed), Biotechnology, Vol 1-2, Verlagchemie.
2. Stanbury, P.E. and Whitaker, A., Principles of Fermentation Technology (1984), Pergamon Press.
3. Pirt, S.J., Principles of Microbial and Cell Cultivation. Blackwell Scientific Publication, London.
4. Moo-young, M., Comprehensive Biotechnology, Vol. 1-4, Pergamon Press, Oxford
5. Casida, L. E., 1984, Industrial Microbiology, Wiley Easterbs, New Delhi
6. Peppler, H. L 1979, Microbial Technology, Vol I and II, Academic Press.
7. Prescott. S.C and Dunn, C. G., 1983 Industrial Microbiology, Reed G. AVI tech books.
8. A. H. Patel. (1985), Industrial Microbiology, Macmillan India Ltd.
9. **Suggested digital platform links:**
   - **http://nsi.gov.in/study-materials/DIIPA_Lecture-2_Role_of_microorganismand_other_conditions_07042020.pdf**
   - **https://www.sciencedirect.com/topics/food-science/food-preservation#:~:text=Second%20Edition)%2C%202003-,Introduction,product%20free%20of%20pathogenic%20microorganisms.**
   - **https://www.technologytimes.pk/2019/03/13/food-preservation-methods/**
   - **https://www.frontiersin.org/articles/10.3389/fmicb.2017.02009/full**
   - **https://www.sciencedirect.com/topics/engineering/downstream-processing**

Course prerequisites: To study this course, a student must have had the subject **Biochemistry & Microbial Physiology** in II Semester.

Suggested Continuous Evaluation Methods:

House Examination/Test: 10 marks

Written Assignment/Presentation/Project/Research Orientation/Term papers/Seminar: 10 Marks

Class performance/ Participate: 5 Marks

Further Suggestions: None

Programme/Class: Diploma	**Year: Second**	**Semester: Third**
Subject: Industrial Microbiology		
Course Code: B017302P	**Course Title:** Fermentation Technology Practical	

Course Learning Outcomes:

After completing the course, the student will be able to:

1. Learn aerobic and anaerobic fermentation
2. Know about Processing & selection of best microbial strains for the industry
3. Gain knowledge of solid state fermentation, shake flask fermentation
4. learn the production of various pharmaceutical products or industrially important product

Credits:2	**Core:** Compulsory
Max. Marks: 25+75	**Min. Passing marks:** as per rules
Total No. of Lectures-Tutorials-Practical(in hours per week):**L-T-P:**0-0-2	

S. No.	Topics	Total No. of Lectures/ Hours (60)
1.	Fungal and Bacterial Fermentation	8
2.	Anaerobic fermentation for wine production	8
3.	Fermentation for the production of Citric acid	8
4.	Fermentation for the production of antibiotics	8
5.	Solid state fermentation for production of enzymes	8
6.	Shake flask fermentation (Study of effect of agitation)	8
7.	Yogurt fermentation	8
8.	Cheese fermentation	4

Suggested readings:

1. Industrial Microbiology (2000) by AH Patel, Macmillan Publishers India
2. Biology of Industrial microorganism (1981) by Arnold L. Domain, Bejamin/ cummings Pub. Co.
3. Industrial Microbiology by Prescott & Dunns, AVI Publishing Company Inc.
4. Industrial Microbiology by Casida LE, New age International (P) Ltd.
5. **Virtual lab links:**
   - **https://www.tandfonline.com/doi/full/10.1080/13102818.2018.1440974**
   - **https://user.eng.umd.edu/~nsw/ench485/lab8.htm**
   - **https://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=1333&context=farms_reports**

Programme/Class: Diploma	**Year: Second**	**Semester: Fourth**
Subject: Industrial Microbiology		
Course Code: B017401T	**Course Title:** Environmental & Agricultural Microbiology	

Course Learning Outcomes:

The student at the completion of the course will be able to:

1. Get acquainted with natural habitats of diverse microbial population. And be familiar with microbial succession and the concept of various examples.
2. Understand how microbes interact among themselves and with higher plants and animals with the help of various examples.
3. Become aware of the important role microbes play in bio-geochemical cycling of essential elements occurring within an ecosystem and its significance.
4. Gain in depth knowledge of different types of solid waste, liquid waste and their management.
5. Get familiar with problems of pollution and applications of clear up technologies for the pollutants.
6. Know about the diverse microbial populations in various natural habitats like soil, air, water.

7. Gain knowledge of the bio-fertilizer and their types.		
Credits: 4	**Core:** Compulsory	
Max. Marks: 25+75	**Min. Passing marks:** as per rules	
Total No. of Lectures-Tutorials-Practical(in hours per week): **L-T-P:** 4-0-0		
Unit	**Topics**	**Total No. of Lectures/ Hours (60)**
I	**Habitat Ecology** Structure and function of ecosystem; Terrestrial environment: soil profile and soil microflora; Aquatic Environment: microflora of fresh water and marine habitats; Atmosphere: Aeromicroflora and dispersion of microbes; Animal Environment: Microbes in/on human body (microbiomes) & animal (Ruminants) body; Extreme habitats: Extremophiles: Microbes thriving at high & low temperature, pH. High hydrostatic & osmotic pressures, salinity and low nutrient level;Microbial succession in decomposition of plant organic matter.	8
II	**Microbial Interactions** Microbe interactions: Mutualism, synergism, commensalism, competition, amensalism, parasitism, predation; Microbe-Plant interaction: positive-negative interaction; Microbe-Animal interaction: positive-negative interaction; Microorganism of rhizosphere, rhizoplane and phylloplane, mycorrhiza (types and its applications).	8
III	**Biogeochemical cycling** Carbon cycle: Microbial degradation of cellulose, hemicellulase, lignin and chitin; Nitrogen cycle: Nitrogen fixation, ammonification, nitrification, denitrification and nitrate reduction; Phosphorous cycle: Phosphate Immobilisation and solubilisation; Sulphur cycle: Microbes involved in sulphur cycle.	8
IV	**Waste management** Solid waste management: Source and type of solid waste, method of solid waste disposal (composting and sanitary landfill), Liquid waste management: composition and strength of sewage (BOD&COD), primary, secondary, (oxidation pond, trickling filter, activated sludge process and septic tank) and tertiary sewage treatment.	8
V	**Microbial Bioremediation and Bioleaching** Principle and degradation of common pesticides, organic (hydrocarbon, oil spills) and inorganic matter, biosurfactants. Copper and iron-ore form available areas of deposits, method of leaching, mechanism and significance.	8
VI	**Water potablity** Treatment and safety of drinking water; Methods to detect potability of water sample:Standard qualitative procedure-MPN test/Presumptive test, confirmed and completed test for	6

	faecal-coliforms Membrane filter technique, Presence/Absence test fecal coliform.	
VII	**Biofertilizer** Definition, Types- Bacterial, Fungal, Phosphate solubiliser, BGA & associative, Industrial biomass production; Mode of application; Advantages and Disadvantages. Mycorrhiza (types and its applications)	6
VIII	**Biopesticides and Biodegradation** Introduction and definition; Types of biopesticides; Integrated pest management (IPM); Mode of action; Factor influencing; Applications, advantages& disadvantages. Biodegradation of Xenobiotics, Bioaccumulation, Biodeterioration.	8

Suggested Readings:

1. AlexanderM., Introduction to soil microbiology, Wiley Eastern limited, New Delhi.
2. Alexopoulas C.J. and MIMS C.W., Introductory Mycology, New age international, New Delhi.
3. Aneja K.R., Experiments in Microbiology, plant pathology, Tissue culture and Mushroom cultivation, New Age International, New Delhi
4. Hurst, C.J., Environmental Microbiology, ASM press, Washington D.C.
5. Mehrotra A.S., Plant Pathology, Tata Mcgraw Hill Publications limited, New Delhi.
6. Pelczar M.J., Chan E.C.S and Kreig N.R., Microbiology, Mcgraw-Hill Book Company, New York.
7. Prescott Lansing M., Harley John P. and Klein Donald A., Microbiology, WCB Mcgraw- Hill, New York.
8. Salle A.J., Fundamental Principles of Bacteriology, Tata Mcgraw-Hill Publishing Company Limited, New Delhi.
9. Stacey R.H. and Evans H.J., Biological Nitrogen Fixation, Chapman and Hall limited, London.
10. Stanier R.Y., Ingraham J.L., General Microbiology, Prentice Hall of India Private Limited, New Delhi.
11. Subbarao N.S., Soil Microroganisms and Plant Growth, Oxford and IBH Publishing Company, New Delhi.
12. Steward W.D.P., Nitrogen Fixation in Plants, The Athlone Press, London.

13. **Suggested digital platform links:**
    - https://www.classcentral.com/tag/microbiology
    - https://www.mooc-list.com/tags/biotechnology
    - https://asm.org/articles/2020/december/virtual-resources-to-teach-microbiology-techniques
    - https://www.futuredirections.org.au/publication/living-soils-role-microorganisms-soil-health
    - https://collegelearners.com/ebooks/agricultural-microbiology-pdf-free-download

Course prerequisites: To study this course, a student must have had the subject **Fermentation Technology** in III Semester.

Suggested Continuous Evaluation Methods:

House Examination/Test: 10 marks
Written Assignment/Presentation/Project/Research Orientation/Term papers/Seminar: 10 Marks
Class performance/Participate: 5 Marks

Further Suggestions: None

Programme/Class: Diploma	**Year: Second**	**Semester: Fourth**
Subject: Industrial Microbiology		
Course Code: B017402P	**Course Title:** Environmental & Agricultural Microbiology Lab	

Course Learning Outcomes:

The student at the completion of the course will be able to:

1. To understand the instruments, microbial techniques and good lab practices for working in a microbiology laboratory.
2. Practical skill in the laboratory experiments in microbiology.
3. Develop skills for identifying microbes and using them for industrial, agricultural and environmental purpose.
4. To prepare slides and stain to see the microbial cell.

Credits: 2	**Core:** Compulsory
Max. Marks: 25+75	**Min. Passing marks:** as per rules

Total No. of Lectures-Tutorials-Practical(in hours per week): **L-T-P:** 0-0-2

S. No.	Topics	Total No. of Lectures/ Hours (60)
1	• Qualitative and quantitative estimation of water. • Qualitative and quantitative examination of sewage water. • Microbial examination of water by coliform, MPN methods. For potable and sewage water.	12
2	● Isolation of microbes (Bacteria, Yeast & Mold) from soil sample at different temperature (28^{o} C & 45^{o} C) ● Isolation of Azotobactor. ● Isolation of Rhizobium from root nodule.	12
3	● Isolation and identification of microorganisms present in various air samples. ● Microscopic observation root colonization by VAM fungi.	12
4	● Study of Plant pathogens. 1. Black rust of wheat 2. White rust of crucifer 3. Leaf curl of tomato 4. Downy mildow 5. Red rot of sugarcane 6. To isolate *Rhizobium* from root nodule.	12
5	Study of permanent slide and life materials ● *Cladosporium* ● *Helmithosporium* ● *Mucor* ● *Curvularia* ● *Alternaria* ● *Geotrichurn* ● *Trichoderma* (Specimens) ● *Rhizopus*	12

Suggested Readings:

1. Agrios A.G. Plant Pathology, Elsevier Academic Press, New Delhi, 2006.
2. Atlas RM and Batha R (2000). Microbial Ecology: Fundamentals & Applications. 4^{th} edition. Benjamin/Cummings Science Publishing, USA.

3. Maier RM, Pepper IL and Gerba Cp (2009). Environmental Microbiology. 2nd edition, Academic Press.
4. Subba Rao NS. (1999). Soil Microbiology, 4th edition. Oxford & IBH Publishing Co. New Delhi.

5. Virtual lab links:

- https://vlab.amrita.edu/?sub=3&brch=73
- https://www.vlab.co.in/ba-nptel-labs-biotechnology-and-biomedical-engineering
- https://opentextbc.ca/virtualscienceresources/chapter/environmental-science/

Detail Syllabus of

B.Sc. III Year

Industrial Microbiology

Programme/Class: Bachelor of Science	Year: Third	Semester: Fifth
Subject: Industrial Microbiology		
Course Code: B017501T	**Course Title:** Industrial Food Microbiology	

Course Learning Outcomes:

1. Upon completion the students will learn about the role of Micro-organism in Industry of food Microbiology.
2. Learn about chemistry and the symptoms of deteriorated food.
3. Assimilate knowledge about Microbial Examination of food.
4. Learn about food preservation techniques.
5. Will be able to monitor food quality and food packaging.

Credits: 4	**Core :** Compulsory
Max. Marks: 25+75	**Min. Passing Marks:** as per rules

Total No. of Lectures-Tutorials-Practical (in hours per week): **L-T-P: 4-0-0**

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Introduction to food & nutrition** History, Scope of Industrial food microbiology; Physiochemical properties of food; Importance and types of microorganisms in food (bacteria, mold and yeast); Intrinsic and extrinsic factors that affect growth and survival of microbes in food, natural flora and source of contamination of foods in general.	8
II	**Chemical composition of food** Carbohydrate, pectic substances, proteins, functional properties of proteins in food, changes in protein, lipids and carbohydrates during processing,	7
III	**Fermented food** Microbiology of: dairy products (cheese, yoghurt); cereal and vegetable products (bread, sauerkraut, pickles); beverages (kanji, vinegar, wine); fermented fish and meat products.	8
IV	**Microorganisms as food** Single cell proteins. prebiotics probiotics and synbiotics: health benefits, types of microorganisms used, probiotic foods available in market. Mushroom cultivation.	8
V	**Food borne diseases food poisoning** *Staphylococcus aureus*, *Clostridium botulinum*, *Vibrio cholerae*, *Escherichia coli* and *Salmonella* infections. Toxins of food borne pathogenic bacteria and fungi.	6
VI	**Food preservation** Basic Principles, Methods (heating, freezing, dehydration, chemical preservatives, radiation). Modern technologies in food preservation, Packaging material.	8
VII	**Microorganisms and milk** Physical and chemical properties of milk; Milk as a substrate for microorganisms; Microbiological analysis of milk – Rapid	8

	Platform test, standard plate count, MBRTtest, alkaline phosphatase enzyme test, DMC; Method of preservation of milk and milk product, pasteurization sterilization and dehydration.	
VIII	**Microbial quality control of food** Total quality management, HACCP for food safety. Indices of food quality (FSSAI, ISO); Microbiological quality standard of food. Introduction to food packaging; Need, role of packaging in extending shelf life of food and food packaging materials.	8

Suggested Readings:

1. Adams & Moss, Food Microbiology, Published by Royal Society of Chemistry, Cambridge, U.K.
2. R.S. Mehrotra – Plant Pathology, Tata Mc-Graw Hill
3. Frazier & Westhoff., Food Microbiology Tata Mc-Graw Hill (2014)
4. Varnam A.H. & Evans M G – Food borne pathogens. Wolfe Publishing House, London
5. B.D. Singh (2015) Biotechnology, Kalyani Publisher
6. Prajapati (2007) Fundamentals of Dairy microbiology, Indian Council of Agricultural Research, NewDelhi
7. Andrew Proctor (2011) Alternatives to conventional food processing. RSC Publisher
8. Arun K. Bhunia & Bibek Ray, Fundamental Food Microbiology, 5th Ed., CRC Press
9. Marwaha S.S. and Arora, J.K. (2000), Food Processing; Biotechnological applications, Asia tech Publishers Inc., New Delhi.
10. Norman N. Potter (1987). Food Science (3rd ed.), New Delhi; CBS publ. and distributors.
11. Luciano P, Sara L, 2016, Food Packaging Materials, Springer Cham Heildelberg, New York.
12. NIIR (2003) Food packaging Technology Handbook, National Institute of Industrial Research Board, Asia Pacific Business Press Inc.
13. Doyle. Michael P, Gonzalez-francisco Diez, Food Microbiology : Fundamentals and frontiers, 5th edition, Hill Colin, available on Wiley online Library.
14. **Suggested digital platform links:**
    - http://www.vlab.co.in
    - http://www.vlab.amrita.edu
    - http://asm.org/articles/2020/december/virtual-resources-to-teach-microiology-techniques

Course prerequisites: To study this course, a student must have had the subject **Environmental & Agricultural Microbiology** in IV Semester.

Suggested Continuous Evaluation Methods:

House Examination/Test : 10 marks
Written Assignment/Presentation/Project/Research Orientation/Term papers/Seminar: 10 Marks
Class performance/Participate: 5 Marks

Further Suggestions:
None

Programme / Class: Bachelor of Science	**Year: Third**	**Semester: Fifth**
Subject: Industrial Microbiology		
Course Code: B017502T	**Course Title:** Immunology & Medical Microbiology	

Course Learning Outcomes:

Upon completion the students will learn

1. The historical development of immunology
2. The components of immune system, Immune responses, features of antigen and antibody, hypersensitivity responses
3. Applications of antibody in diagnosis and therapy, and antigen-antibody reactions.
4. The historical development of medical microbiology
5. The importance of microorganisms in life.
6. The microorganisms associated with various infectious diseases.
7. Antibiotic resistance
8. Processes of sample collection and processing

Credits: 4	**Core:** Compulsory
Max. Marks: 25+75	**Min. Passing Marks:** as per rule

Total No. of Lectures-Tutorials-Practical (in hours per week): **L-T-P: 4-0-0**

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Overview of Immunology** History of immunology, Physical and physiological barriers, Innate and Acquired immunity, Organs and Cells of Immune system.	7
II	**Nonspecific immunity & Specific Immunity** Phagocytosis, Complement System Proteins, Complement System Activation by Classical, Alternate and Lectin Pathway, Humoral and Cell Mediated Immunity, Active And Passive Immunity	8
III	**Antigen, Immunogens, Antibody and MHC** Antigen Characteristics, Types of Antigens, Adjuvants, Immunogenicity and Antigenicity, Classes of immunoglobulin-structure and function, Major Histocompatibility Complex: Types-structure.	8
IV	**Immunotherapy, Immunodiagnostic, Hypersensitivity** Antibodies as therapeutic substances, Application of antibodies in diagnostics (Antigen-Antibody Reactions: Agglutination and immunodiffusion). Types of Hypersensitivity, Mechanism of hypersensitivities with examples,	8
V	**History of Medical Microbiology** Contribution of pioneers in the field of Medical Microbiology, Normal Microflora of human body: skin, mouth, alimentary canal and gintourinary tract	6
VI	**Food borne infectious pathogens** Diseases caused by bacteria (*Clostridium botulinum*, *Brucella*, *Campylobacter jejuni*, *Vibrio*, *E. coli*, *Salmonella*); fungi (*Aspergillus*, *Candida*); Virus (Hepatitis, Rotavirus)	10

VII	**Antibiotics and Chemotherapeutics** Historical development of chemotherapeutic and antibiotic substances, Major antimicrobial agents, Mode of action of chemotherapeutic and antibiotic substances.	6
VIII	**Antibiotic resistance, Sample collection and processing** Drug resistance, Mechanism of antibiotic resistance, Antibiotic susceptibility assay. Collection and transport of appropriate clinical sample specimen for clinical diagnostics	7

Suggested Readings:

1. Kindt, Goldsby and Osborne. Kuby's Immunology. WH Freeman& Company,
2. Roitt I,Brostoff, J and Male D.Immunology, 6th edition, 2001, Mosby, London.
3. Ramesh SR, Immunology. Mc Graw Hill Publications.
4. Madhavee LP, A Textbook of Immunology, S Chand Publisher.
5. Reddy R, Textbook of Immunology, 3rd edition, AITBS Publisher.
6. Annadurai, A. A textbook of Immunology and Immunotechnology. S. Chnd
7. Ananthanarayanan R and Panicker C K. Textbook of Microbiology. Orient Longman.
8. Baveja, CP. Text book of Microbiology. Arya publications.
9. Ken S.Rosenthal, Patrick R.Murray, and Michael A.Pfaller. Medical Microbiology 7th Edition, Elsevier
10. Karen C.Carroll, Geo.Brooks, Stephen Morse, and Janet Butel.Jawetz, Melinck, &Adelberg's Medical Microbiology, Lang
11. **Suggested digital platform links:**
    - https://www.futurelearn.com/courses/basic-concepts-in-microbiology-and-clinical-pharmacology-of-antimicrobials
    - https://vlab.amrita.edu/?sub=3&rch=73
    - https://www.mooc-list.co/tags/pathology
    - https://online.creighton.ed/program/medical-microbioogy-and-immunology-ms
    - https://www.mcgill.ca/microimm/undergraduate-programs/courses
    - https://oline.creighton.edu/program/medical-microbiology-and-immunology-ms

Course prerequisites: To study this course, a student must have had the subject **Environmental & Agricultural Microbiology** in IV Semester.

Suggested Continuous Evaluation Methods:

House Examination/Test: 10 marks
Written Assignment/Presentation/Project/Research Orientation/Term papers/Seminar: 10 Marks
Class performance/Participate: 5 Marks

Further Suggestions:
None

Programme / Class: Bachelors of Science	**Year: Third**	**Semester: Fifth**
Subject: Industrial Microbiology		
Course Code: B017503P	**Course Title:** Experiments in Food and Immunology & Medical Microbiology	

Course Learning Outcomes:

Upon completion of the practical course in medical microbiology and immunology the students will learn about

1. The culture of microorganisms used in Food microbiology.
2. The preparation of culture media, microorganisms associated with human body, characterization of microorganisms associated with disease.
3. Antigen- antibody interaction
4. Learning of the application of antibodies for diagnostic purposes, antibiotic sensitivity test and resistance transfer.

Credits: 2	**Core:** Compulsory
Max. Marks: 25+75	**Min. Passing Marks:** as per rules

Total No. of Lectures-Tutorials-Practical (in hours per week): **L-T-P:0-0-2**

S. No.	Objectives	Total No. of Lectures/ Hours (60)
1	Preparation of blood agar, chocolate agar, and other media required for medically important microorganisms	12
2	Isolation and characterization of skin normal microflora	8
3	Bacteriological analysis, isolation and characterization of bacteria and fungi from fresh and spoiled food products	12
4	Determination of the quality of milk by MBRT	4
5	Demonstration of serological tests: blood groups, Rh factor determination, pregnancy test, Widal, VDRL, ELISA	12
6	Antibiotic sensitivity test and MIC determination	12

Suggested Readings:

1. Hudson L, and Hay FC, Practical Immunology, 3rd edition, Wiley.
2. Noel R. Rose, Herman Friedman, John L. Fahey., Manual of Clinical Laboratory Immunology, 3rd edition, ASM. Ed.3; 1986.
3. Talwar GP and Gupta SK, A Handbook of Practical and Clinical Immunology, Vol.I-II; CBS Publishers and Distributors. Delhi
4. Aneja KR, Experiments in Microbiology, Plant Pathology and Biotechnology, Ist edition, New Age International Publisher
5. Randhawa VS, Practicals and Viva in Medical Microbiology, Harcourt India Pvt. Ltd.
6. **Virtual lab links:**
    - http://www.vlab.co.in
    - http://www.vlab.iitb.ac.in
    - http://www.onlinelabs.in
    - http://www.vlab.amrita.edu
    - http://asm.org/articles/2020/december/virtual-resources-to-teach-microiology-techniques

Programme/Class: Bachelor of Science	**Year: Third**	**Semester: Sixth**
Subject: Industrial Microbiology		
Course Code: B017601T	**Course Title:** Molecular Biology and Microbial Genetics	

Course Learning Outcomes:

At the end of the course, the student will be able to:

1. Distinguish in prokaryotic cellular structure and functional components of cells, as well as the dissimilarities in genome organization between prokaryotes and eukaryotes.
2. Describe the replication, transmission, and action mechanisms of chromosomal and extrachromosomal genes and sequences.
3. Recognize and distinguish genetic regulatory mechanisms at various levels
4. Gain an understanding of how internal and external signals regulate gene expression, influence microbial diversity, and shape microbial communities and their environments.
5. Describe the processes that lead to mutations and other genetic changes.

Credits:4	**Core:** Compulsory
Max. Marks: 25+75	**Min. Passing marks:** as per rules

Total No. of Lectures-Tutorials-Practical(in hours per week):**L-T-P:**4-0-0

Unit	Topics	Total No. of Lectures/ Hours (60)
I	**Overview of the genome organization** DNA/and RNA as genetic material, DNA double helix structure salient features, types of DNA. RNA Structure. Denaturation and renaturation, cot curves. DNA topology: linking number, topoisomerases. DNA organization in prokaryotes, viruses, eukaryotes.	6
II	**DNA Replication in Prokaryotes and Eukaryotes** Bidirectional and unidirectional replication, semi-conservative and semi-discontinuous replication. Mechanism of DNA replication, Replication of chromosome ends.	6
III	**Transcription in Prokaryotes and Eukaryotes** Concept of transcription unit. General transcription process in prokaryotes and eukaryotes; Post-Transcriptional modification in eukaryotes, Aternative splicing mechanism, RNA interference	8
IV	**Translation in prokaryotes and eukaryotes** Ribosome structure, tRNA structure and processing, Mechanisms of translation in both prokaryotes and eukaryotes, Genetic code, Wobble hypothesis, Fidelity of translation	8
V	**Regulation of gene expression** in prokaryotes and eukaryotes Overview of regulation of gene expression, Regulation of gene expression by DNA methylation, histone acetylation and histone methylation mechanisms; Transcription control mechanisms, Inducible Operon System, Repressible Operon System, Translation control mechanisms.	10
VI	**Plasmids in prokaryotes and eukaryotes** Plasmid replication and partitioning, host range, plasmid incompatibility, plasmid amplification, regulation of plasmid copy number, curing of plasmids. Types of plasmids.	6
VII	**Bacterial gene exchange processes** Mechanisms of Genetic Exchange, Horizontal gene transfer, Transformation; Conjugation; Transduction, Complementation.	8

VIII	**Mutations, mutagenesis and repair** Types of mutations, Physical and chemical mutagens. Loss and gain of function mutants. Reversion and suppression, Uses of mutations. Ames Test, DNA repair mechanism	8

Suggested Readings:

1. Watson, J. et. Al. 2004. Molecular Biology of the Gene,5th Edition, CSHL Press, New York.
2. Conn, E., & Stumpf, P. 2009.Outlines of Biochemistry, 5Th Ed. Wiley India Pvt. Limited.
3. T A Brown.2001. Essential Molecular Biology. Oxford University Press, USA
4. Brock, T.D. 1990. The Emergence of Bacterial Genetics, Cold Spring Harbor Lab Press.
5. Ptashne, M. 2002. Genes and Signals, Cold Spring Harbor Laboratory Press.
6. Miller, J.R. 1992. A Short Course in Bacterial Genetics: Lab Manual, Cold Spring Harbor Laboratory Press
7. **Suggested digital platform links:**
    - https://www.classcentral.com/tag/microbiology
    - http://www.mooc.list.com/tag/molecular-biology
    - http://www.mooc.list.com/course/microbiology.sayloro
    - https://lipidnanostructuresgroup.weely.com
    - http://www.mooc.list.com/microbial
    - https://open.umn.edu/opentextbooks/textbooks/biochemistry-free-for-all-ahern

Course prerequisites: To study this course, a student must have had the subject **Industrial Food Microbiology and Immunology & Medical Microbiology** in V Semester.

Suggested Continuous Evaluation Methods:

House Examination/Test:10 marks

Written Assignment/Presentation/Project/Research Orientation/Term papers/Seminar: 10 marks

Class performance/Participate: 5Marks

Further Suggestions: None

Programme/Class: Bachelors Degree	**Year: Third**	**Semester: Sixth**
Subject: Industrial Microbiology		
Course Code: B017602T	**Course Title:** Computers, Bioinformatics & Biostatistics	

Course Learning Outcomes:

1. Develop basic understandings about computers, its working and computer languages.
2. The students will be made aware of theoretical concepts of bioinformatics.
3. Will understand the use of statistics in the field of industrial microbiology.

Credits: 4	**Core:** Compulsory
Max. Marks: 25+75	**Min. Passing marks:** as per rules

Total No. of Lectures-Tutorials-Practical(in hours per week): **L-T-P:** 4-0-0

Unit	Topics	Total No. of Lectures/Hours (60)
I	**Introduction to Computers** Classification, Computer generation, low medium and high level languages, computer memory and its type. Data representation & storage.	6
II	**Microsoft Excel** Data entry, graphs, aggregate functions, conversion devices, secondary storage media.	8

III	**Bioinformatics** Overview and scope of bioinformatics, Genomics, Transcriptomics Proteomics, Metabolomics, Programming languages in bioinformatics.	7
IV	**Introduction to biological database** Primary secondary & composite data base. Computer tools for sequence analysis.	7
V	**Sequencing and alignment** Finding and retrieving sequences (SRS, Entrez). Gene sequencing, Protein sequencing Sequence submission tools. Similarity searching, pairwise and multiple sequence alignment	8
VI	**Biostatistics** Definition, Statistical Methods, compilation, classification, tabulation and application in Life Science, Graphical representation, Introduction to probability theory & distributions, Limitation and uses of statistics	8
VII	**Biometry** Data, Sample, Population, random sampling stratified systematic and cluster sampling procedure frequency distribution. Central tendency, Arithmetic mean, Mode and Median.	8
VIII	**Measurement of dispersion** Coefficient of variation standard deviation, standard error of mean, Test of significance: Chi-Square test. Computer application of biostatistics – MS Excel and SPSS.	8

Suggested Readings:

1. Ramesh Bangia, Learning Computer Fundamental. Khanna Book Publishers.
2. Bioinformatics Paperback – 1 January, 2015 by Dr. Archana Pandeya (Author), Santosh Choubey (Editor), & 2 More. Hindi AISECT Ltd.
3. Ghosh, Z., Mallick, B. (2008). Bioinformatics – Principles and Application, 1st edition. New Delhi, Delhi: Oxford University Press.
4. Baxevanis, A.D. and Ouellette, B.F., John (2005). Bioinformatics: A Practical Guide to the analysis of Genes, Protiens, 3rd edition. New Jersey, U.S. : Wiley & Sons, Inc.
5. Roy, D. (2009). Bioinformatics, Ist Edition. New Delhi, Delhi: Narosa Publication House.
6. Alexis and Mahtew Leon, Fundamentals of Information Technology Leon Vikas.
7. R. Rangaswami (2009) A text book of Agriculture Statistics, New Age International (P) Limited, Hyderabad.
8. Snedecor GW. & Cochran WG. (1989) Statistical Methods. Iowa State University Press.
9. V.K. Kapoor (2007) Fundamentals of Applied statistics by Sultan chand and sons, New Delhi-110002
10. Gupta, S.c. (2016) Fundamentals of Statistics Himalaya Publishing House Mumbai - 400004
11. Sharma A.K. 2005. Text Book of Biostatistics I, Discovery Publishing House.
12. Annadurai, B. 2007. Text Book of Biostatistics. New age International
13. Gurumani, N. 2010. An Introduction to Biostatistics (2nd Edn.) MJP Publishers.
14. Heggins and Taylor. Bioinformatics. OUP.
15. Pradeep Sinha and Priti Sinha, Computer Fundamentals, BPB Publications.
16. **Suggested digital platform links:**
    - https://www.classcentral.com/course/swayam-computer-fundamentals-13950
    - https://www.scielo.br/j/rbof/a/b9DM74ZBhb4CmK7CQ35wF4R/?format=pdf&lang=en
    - https://rsh249.github.io/bioinformatics/
    - https://www.sciencedirect.com/topics/medicine-and-dentistry/biometry
    - https://www.statisticshowto.com/probability-and-statistics/spss-tutorial-beginners/

Course prerequisites: To study this course, a student must have had the subject **Industrial Food Microbiology and Immunology & Medical Microbiology** in V Semester.
Suggested Continuous Evaluation Methods: **House Examination/Test:** 10 marks **Written Assignment/Presentation/Project/Research Orientation/Term papers/Seminar:** 10 Marks **Class performance/Participate:** 5 Marks
Further Suggestions: None

Programme/ Class: Bachelors in Science	**Year: Third**	**Semester: Sixth**
Subject: Industrial Microbiology		
Course Code: B017603P	**Course Title:** Molecular Biology and Bioinformatics Lab	

Course Learning Outcomes:

The student upon the completion of the course be able to:

1. Understand the fundamentals of molecular biology and genetic research.
2. Use some basic equipment in a molecular biology laboratory.
3. Extract genomic DNA from microbes using molecular biology techniques
4. Measure DNA and verify purity using UV spectrometer and electrophoresis.
5. Understand the basic principle of plasmid isolation and their conformations using electrophoresis.
6. Understand the mutagenic effect of chemical and physical agents and perform test to identify mutagenic effect of chemicals

Credits:2	**Core:** Compulsory
Max. Marks: 25+75	**Min. Passing marks:** as per rules

Total No. of Lectures-Tutorials-Practical (in hours per week): **L-T-P:**0-0-2

S. No.	Objectives	Total No. of Lectures/ Hours (60)
1	Isolation of genomic DNA from *E. coli* and analysis by agarose gel electrophoresis.	10
2	Estimation of DNA using diphenylamine reagent.	10
3	Resolution of proteins by polyacrylamide gel electrophoresis (SDS-PAGE) and visualization using coomassie dye.	10
4	Study of the effect of chemical (nitrous acid) and physical (UV) mutagens on bacterial cells.	10
5	Acquaintance with the bioinformatics websites	10
6	Sequence alignment using clustal W2, Clustal Omega	10

Suggested readings:

1. Michael Wink, An Introduction to Molecular Biotechnology (2nd), 2012. ISBN: 9783527326372, TX Wiley-Blackwell.
2. Seidman & Moore, Basic Laboratory Methods for Biotechnology: Textbook & Laboratory Reference, 2nd edition. 2009. Prentice Hall. ISBN: 0321570146.
3. Sambrook J and Russell DW., Molecular Cloning: A Laboratory Manual. 4th Edition, 2004, Cold Spring Harbour Laboratory press.
4. **Virtual lab links:**
   - https://www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/ames-test
   - https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4846332/
   - https://www.ebi.ac.uk/Tools/msa/clustalo/
   - https://www.ebi.ac.uk/Tools/msa/clustalw2/