A.C.-03.08.2022
Appendix-92

UNIVERSITY OF DELHI

DEPARTMENT : MICROBIOLOGY

COURSE NAME: BSc. Hons.

(SEMESTER -I)

Based on

Undergraduate Curriculum Framework 2022 (UGCF)

(Effective from Academic Year 2022-23)

DSC & GE

Course Title	Nature of the Course	Total Credits	Components			Eligibility Criteria/ Prerequisite	**Contents of the course and reference is in**
			Lecture	Tutorial	Practical		
Introduction to the Microbial World	DSC (Core)	4	3	0	1	Class XII pass with Biology/ Biotechnology/ Biochemistry	Annexure-I
Basic Bacteriology	DSC (Core)	4	3	0	1	-do-	
Biochemistry of Carbohydrates and Lipids	DSC (Core)	4	3	0	1	-do-	
Introduction and Scope of Microbiology	GE	4	2	0	2	None	Annexure-II
Microbes in Health and Hygiene	GE	4	2	0	2	Class XII pass with Biology/ Biotechnology/ Biochemistry	
Food Fermentation and Preservation Techniques	GE	4	2	0	2	-do-	
Microbial Quality Control and Testing	GE	4	2	0	2	-do-	
Microbes in Animal Health	GE	4	2	0	2	-do-	

MICROB-DSC101

INTRODUCTION TO THE MICROBIAL WORLD

Marks: 100 (Theory = 75 marks
Practicals = 25 marks)

Duration: Theory = 45 hours (3 credits)
Practicals = 30 hours (1 credit)

Course Objectives:

The main objective of this course is to introduce students to the world of microorganisms. Students will be made familiar with the major milestones that led to the shaping of microbiology as a distinct discipline of science. Students will gain insights into the diversity of microorganisms, understand their structural features, and appreciate the role of microorganisms in our day-to-day lives as well as in the sustenance of life on earth.

Pre-requisite: Student should have studied Biology/ Biotechnology/ Biochemistry in 12th standard

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

CO1: Discuss the developments that led to the emergence of microbiology as a scientific discipline.

CO2: Understand current systems of classification being used for microorganisms and learn about cell organization in microorganisms.

CO3: Discourse on acellular forms of life such as viruses, viroids and prions.

CO4: Converse actively on the diversity, distribution, cell structure, reproduction and economic importance of protists.

CO5: Deliver information on the diversity, distribution, structure, life cycles and economic importance of fungi.

CO6: Appreciate the extensive and impressive impact of microorganisms in our day-to-day life and become aware of the vast scope of microbiology and its allied fields.

Contents:

Theory: **45 hours**

Unit 1: The Evolution of Microbiology as a Discipline of Science: The discovery of microorganisms, contributions of Anton van Leeuwenhoek, spontaneous generation vs. biogenesis, the germ theory of disease, the golden era of microbiology and major developments in the different fields of Microbiology in the late 20th century. Key contributions of the following scientists: Louis Pasteur, Robert Koch, Joseph Lister, Edward Jenner, Elie Metchnikoff, Ronald Ross, Dmitri Ivanovsky, Martinus Beijerinck, Stanley Prusiner, Paul Ehrlich, Alexander Fleming, Selman Waksman, Sergei N Winogradsky and Anand Mohan Chakraborty. **9**

Unit 2: Classification Systems: Whittaker's five kingdom classification system and Carl Woese's three domain classification system. Overview of acellular (viruses) and cellular micro-organisms (eubacteria, archaea, protista, fungi). Prokaryotic and Eukaryotic cell structure**.** **3**

Unit 3: Acellular microorganisms and protista:

Brief introduction to viruses: Structure (genetic material, capsid symmetry, envelope), host range, cultivation, bacteriophages (lytic and lysogenic). General characteristics of viroids and prions.

Algae: General characteristics including occurrence and thallus organization. Criteria for classification of algae: cell wall composition, pigments, flagellation, food reserves. Cell structure and reproduction of *Chlamydomonas* and *Chlorella*. Economic importance of algae.

Protozoa: General characteristics of protozoa with a reference to cell structure, modes of locomotion, modes of nutrition, and modes of reproduction. Morphology and importance of *Entamoeba histolytica, Tetrahymena* and *Giardia*. Ecological importance of protozoa.

Acellular and Cellular slime molds: a brief account **14**

Unit 4: Fungi: General characteristics: morphology, cell structure, nutritional requirements, cultivation, preservation and reproduction (asexual and sexual cycles). Structure, life cycle and economic importance of *Saccharomyce*s, *Rhizopus, Aspergillus,* and *Agaricus*. **9**

Unit 5: The scope of microbiology: an overview. Food and dairy industry: fermented foods, single cell protein. Human health and medicine: human microbiome, probiotics, vaccines, phage therapy. Microbes in environment: bioremediation, bioleaching, waste management, biogas, bioethanol, carbon sequestration. Microbes in agriculture: biocomposting, biofertilizers, biopesticides. Industrially important microbial products: organic acids, amino acids, antibiotics, enzymes, polysaccharides. Space microbiology: Current developments. **10**

Practicals: **30 hours**

Unit 1: Principles of Good Laboratory Practice (GLP) **and Introduction to aseptic techniques**: Principles of Good Microbiological Laboratory Practices (GMLP). Concept of biosafety levels (BSLs). Work practices, safety equipment and protective measures to be used in laboratories of the different categories of biosafety levels BSL-1 to BSL-4. Microorganism risk groups: BSL-1 to BSL-4 microorganisms. Methods of disposal of microbial cultures. Sterilization by moist heat, mechanical (filtration), irradiation (UV), chemical (alcohol). Instruments for sterilization: Principle, working and applications of autoclave and hot air oven.

15

Unit 2: Study of eukaryotic microorganisms: To study the morphological features and reproductive structures of the following using permanent slides/photographs: Fungi: *Rhizopus*, *Aspergillus, Penicillium, Saccharomyces.* Algae: *Chlamydomonas*, *Chlorella, Spirogyra.* Protozoa: *Amoeba, Paramecium, Entamoeba histolytica, Giardia.* To prepare temporary mounts of any two fungi and two algae from those mentioned above. **15**

Suggested Reading:

Theory:

1. Brock Biology of Microorganisms by M.T. Madigan,J. Aiyer,D. Buckley,W.Sattley and D. Stahl.16th edition. Pearson, USA. 2021.

2. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGrawHill Higher Education, USA. 2019.

3. Microbiology: An Introduction by G.J. Tortora, B.R. Funke,and C.L. Case. 13th edition. Pearson, USA. 2018.

4. Algal Biotechnology: Products and Processes. Edited by Bux F. and Chisti Y. 1st edition. Springer, Switzerland. 2016.

5. Principles of Microbiology by R. M. Atlas. 2nd edition. W.M.T. Brown Publishers, USA.1997.

6. Microbiology by M. J. Pelczar, E. C. S. Chan and N. R. Krieg. 5th edition. McGraw Hill,USA. 1993.

Practicals:

1. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition. Pearson Education, USA. 2020.

2. Basic Lab Manual of Microbiology, Biochemistry and Molecular Biology by A. Ray and R. Mukherjee. Taurean Publisher, India. 2019.

3. Benson's Microbiological applications: Laboratory manual in general microbiology by A.E. Brown and H. Smith H. 15th edition. McGraw-Hill Education, USA. 2022.

4. Manual of Microbiology: Tools & Techniques by A.K. Sharma. 1st edition. Ane Books, India. 2007.

Facilitating the achievement of course learning objectives

S. No.	Course learning outcomes	Teaching and learning activities	Assessment tasks*
1.	Discuss the developments that led to the emergence of microbiology as a scientific discipline	Discussion on the discovery of microorganisms and the controversy over spontaneous generation, discoveries in the golden age of microbiology and developments in the field in late 20th century.	Quiz, match the following, and identification of scientists through photographs
2.	Understand current systems of classification being used for microorganisms and learn about cell organization in microorganisms	Interactive lectures on different systems of classification, prokaryotic and eukaryotic cell structure, acellular and cellular microorganisms using visual aids and power point presentations.	Multiple choice questions and diagrammatic representations.
3.	Discourse on acellular forms of life such as viruses, viroids and prions.	Interactive lectures on helical, icosahedral and complex capsid symmetry of viruses, host range and cultivation of viruses. Differences between viroids and prions.	Diagrammatic depiction of various symmetry types, and identification using electron micrographs.

4.	Converse actively on the diversity, distribution, cell structure, reproduction and economic importance of protists of protists	Detailed discussion on the general characteristics and economic importance of algae, protozoa, and slime molds.	Class test on definitions and short notes.
5.	Deliver information on the diversity, distribution, structure, life cycles and economic importance of fungi	Interactive lectures on cell structure and reproduction in fungi with the help of charts and visual aids. Group discussion on the economic importance of common fungi.	Drawing diagrams of morphology and life cycles of common fungal genera. Quiz on the economic importance of fungi and fungal associations.
6.	Appreciate the extensive and impressive impact of microorganisms in our day-to-day life and become aware of the vast scope of microbiology and its allied fields.	Discussion on the the scope of microbiology in various fields, taking practical examples from day-to-day life.	Essay writing and poster making on scope of microbiology highlighting latest interesting findings of practical importance.

***Assessment tasks listed here are indicative and may vary**

MICROB-DSC102

BASIC BACTERIOLOGY

Marks: 100 (Theory = 75 marks
Practicals = 25 marks)

Duration: Theory = 45 hours (3 credits)
Practicals = 30 hours (1 credit)

Course Objectives:

The main objective of this course is for students to acquire in-depth knowledge of bacterial cell structure and organization, cultivation methods and growth patterns, and reproduction. Further, the student gains insights into the vastness of bacterial diversity and its significance.

Pre-requisite: Student should have studied Biology/ Biotechnology/ Biochemistry in 12th standard

Course learning Outcomes:

Upon successful completion of the course the students will be able to:

CO1: Evaluate the morphological features and cellular organization of bacteria and archaea, and distinguish between cell wall and cell membrane compositions of gram positive bacteria, gram negative bacteria, and archaea. Will gain insights into the roles of enzymes and antibiotics affecting cell wall structure as well as the formation of spheroplasts, protoplasts, and L forms.

CO2: Isolate pure bacterial cultures and enumerate bacteria using serial dilution and plating techniques. Will learn about various culture media and methods employed to maintain bacterial cultures and preserve bacteria.

CO3: Discourse on the different phases of bacterial growth, and will understand the consequences of binary fission as a means of reproduction. Will learn about various nutritional and physical factors affecting bacterial growth.

CO4: Prepare various types of media; understand the use of membrane filtration to sterilize heat sensitive media components; have hands-on experience of isolating bacteria and fungi from air.

CO5: Streak bacterial cultures on nutrient medium, prepare bacterial slants and stabs, and enumerate bacteria by different plating methods.

Contents:

Theory: **45 hours**

Unit 1: Structure and organization of the bacterial cell wall and appendages: Shapes, sizes and arrangements of bacterial cells. Cell wall and cell membrane organization: Structure of cell wall in Eubacteria and Archaea, difference between cell wall structure and composition of Gram positive versus Gram-negative bacterial, structure of outer membrane, difference between eubacterial and archaeal cell membranes. Bacteria lacking cell walls, action of antibiotics and enzymes on bacterial cell wall, formation of protoplasts, spheroplasts and L forms. Cell envelope layers outside the cell wall: capsule, slime layer, glycocalyx, S-layers. External appendages**:** flagella, fimbriae and pili. **15**

Unit 2: Cytoplasmic organelles: ribosomes, mesosomes, nucleoid, chromosome and plasmids, intracytoplasmic membranes, inclusions (storage inclusions: PHB, polyphosphate granules, sulfur globules, cyanophycin granules; micro-compartments: Carboxysome; other inclusions: magnetosome, gas vacuole). **10**

Unit 3: Bacteriological techniques: Culture media: Chemical types (synthetic and complex), Functional types (supportive and enriched, selective and differential). Cultivation of aerobes and anaerobes, concept of viable but non culturable bacteria (VBNC). Culturing and Preservation methods: Streaking of bacterial culture, spread-plating, serial dilution plating, counting viable cells. Enrichment culture technique. Preservation of bacteria and maintenance of stock cultures. Microbial culture collection centers (ATCC and MTCC). **8**

Unit 4: Bacterial growth and reproduction: Different phases of bacterial growth in a batch culture**,** determination of generation time, analysis of growth rate. Factors affecting bacterial growth: Nutritional and physical factors. Endospore: Structure, formation, stages of sporulation and germination of endospore. Methods of asexual reproduction: budding, fission and fragmentation. **12**

Practicals: **30 hours**

Unit 1: Introduction to bacterial growth and analysis: Principle, working and applications of instruments used in cultivation and morphological analysis of microorganisms: bacteriological and BOD incubators, light microscope (using simple staining of bacteria). Concept of laminar flow: biological safety cabinets of levels 1 to 4.

Preparation of media and capture of aeroflora: Preparation of Synthetic medium (minimal medium) and Complex media (nutrient agar, potato dextrose agar, MacConkey agar). Capture of aero-microflora on nutrient agar and potato dextrose agar plates.

15

Unit 2: Isolation, preservation and quantitation of bacteria: Isolation of pure cultures of bacteria by Quadrant streaking method on nutrient agar plates. Preparation of bacterial culture slants and stabs on nutrient agar. Preservation of bacterial cultures by preparation of glycerol stocks. **15**

Suggested Reading:

Theory:

1. Brock Biology of Microorganisms by M.T. Madigan,J. Aiyer,D. Buckley,W.Sattley and D. Stahl.16th edition. Pearson, USA. 2021.
2. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGrawHill Higher Education, USA. 2019.
3. Microbiology: Principles and Explorations by J.G. Black and L.J. Black. 10th edition. Wiley, USA. 2019.
4. Microbiology: An Introduction by G.J. Tortora, B.R. Funke,and C.L. Case. 13th edition. Pearson, USA. 2018.
5. Principles of Microbiology by R. M. Atlas. 2nd edition. W.M.T. Brown Publishers, USA.

1997.

6. Microbiology by M. J. Pelczar, E. C. S. Chan and N. R. Krieg. 5th edition. McGraw Hill, USA. 1993.

Practicals:

1. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition. Pearson Education, USA. 2020.

2. Basic Lab Manual of Microbiology, Biochemistry and Molecular Biology by A. Ray and R. Mukherjee. Taurean Publisher, India. 2019.

3. Benson's Microbiological applications: Laboratory manual in general microbiology by A.E. Brown and H. Smith H. 15th edition. McGraw-Hill Education, USA. 2022.

4. Manual of Microbiology: Tools & Techniques by A.K. Sharma. 1st edition. Ane Books, India. 2007.

Facilitating the achievement of Course Learning Outcomes

S. no.	Course Learning Outcomes	Teaching and Learning activity	Assessment Tasks
1.	Evaluate the morphological features and cellular organization of bacteria and archaea, and distinguish between cell wall and cell membrane compositions of gram positive bacteria, gram negative bacteria, and archaea. Will gain insights into the roles of enzymes and antibiotics affecting cell wall structure as well as the formation of spheroplasts, protoplasts, and L forms	PowerPoint presentations/ videos, pictures showing bacterial cells and their components. Explaining differences between Gram+ve and Gram-ve bacteria; eubacterial and archaebacterial structures with the help of diagrams and discussion of the action of antibiotics and enzymes on cell wall.	Test based on diagrams ofvarious cell components and their differences.
2.	Isolate pure bacterial cultures and enumerate bacteria using serial dilution and plating techniques. Will learn about various culture media and methods employed to maintain bacterial cultures and preserve bacteria.	Demonstration of various techniques for isolation and culturing of bacteria. Discussion for comparing of methods of preservation of bacteria.	Evaluation of streaking/spread plate / serial dilution plating techniques.

3.	Discourse on the different phases of bacterial growth, and will understand the consequences of binary fission as a means of reproduction. Will learn about various nutritional and physical factors affecting bacterial growth.	Class lectures on mathematical and graphical expression of changes in bacterial populations by asexual reproduction. Calculation of generation time and growth rate to be explained.	MCQ /Quiz based on examples of asexual reproduction and growth curve.
4.	Prepare various types of media; understand the use of membrane filtration to sterilize heat sensitive media components; have hands-on experience of isolating bacteria and fungi from air.	Weighing media components, dissolving them, setting pH and sterilization of media using autoclave along with learning about the abundance of microbes in air	Testing for sterile media preparation and membrane filtration technique
5.	Streak bacterial cultures on nutrient medium, prepare bacterial slants and stabs, and enumerate bacteria by different plating methods.	Preparation of serial dilution, plating methods will enable students get good practice in inoculating/subculturing bacteria	Testing efficacy of working under aseptic conditions to minimize contaminations of culture plates, observing purity of cultures and learning to purify mixed cultures

*__Assessment tasks are indicative and may vary__

MICROB-DSC103
BIOCHEMISTRY OF CARBOHYDRATES AND LIPIDS

Marks: 100 (Theory = 75 marks Practicals = 25 marks) **Duration: Theory = 45 hours (3 credits) Practicals = 30 hours (1 credit)**

Course Objectives:

The major objective of this course is to enable the students to develop a clear understanding of the structures and properties of biomolecules: proteins, lipids, carbohydrates and nucleic acids, and lays the foundation for a basic understanding of cellular processes. The students will gain an understanding of the principles of thermodynamics and bioenergetics, and will be introduced to the basic concepts of enzymes and enzyme kinetics. This course will empower the students with essential knowledge to support learning in subsequent courses offered in the program.

Pre-requisite: Student should have studied Biology/ Biotechnology/ Biochemistry in 12th standard

Course Learning Outcomes:

Upon successful completion of the course, the student will be able to:

CO1: Explain the principles of thermodynamics as applied to biological systems and will be able to comment on the rate constants and feasibility of biochemical reactions by calculating free energy changes.

CO2: Describe the structures and properties of various types of carbohydrates and will be able to relate the structures of simple and complex carbohydrates to their wide range of functions. Will gain knowledge of the role of sugars and their derivatives in formation of macromolecules /supramolecular complexes.

CO3: Converse on the building block of lipids: fatty acids and their properties. Will acquire a clear understanding of the structures, properties and functions of storage and membrane lipids. Will learn of different types of lipid aggregates and their applications.

CO4: Prepare buffers and solutions of different molarity and normality and will be adept in the use of fine weighing balances and pH meter.

CO5: Analyze foodstuff for their microchemical composition, and will be able to detect the presence of carbohydrates and fats in samples by performing qualitative tests. Will become familiar with the use of spectrophotometer.

Contents:

Theory **45 hours**

Unit 1: Bioenergetics and thermodynamics: Laws of thermodynamics. Gibbs free energy: exergonic and endergonic reactions. Enthalpy: exothermic and endothermic reactions. Entropy, standard free energy change and actual free energy change, equilibrium constant and spontaneous reactions. Coupled reactions and additive nature of standard free energy change. Energy rich compounds: ATP, BPGA, Acetyl

CoA. **9**

Unit 2: Carbohydrates: Introduction to mono-, di- and poly-saccharides. Monosaccharides: aldoses and ketoses. Stereoisomers: enantiomers, epimers, diastereoisomers, mutarotation and anomers. Fischer and Haworth formulae of sugars. Sugar derivative: O-,N-glycosides. Disaccharides: Structures and properties of maltose, lactose, and sucrose reducing and non- reducing sugars. Polysaccharides: storage polysaccharides (starch and glycogen), structural polysaccharides (cellulose, chitin, peptidoglycan, pectin). **15**

Unit 3: Storage Lipids: Introduction to storage and structural lipids. Storage lipids: triacylglycerols, building blocks, fatty acids structure and properties, essential fatty acids, saponification.

8

Unit 4: Structural Lipids: Membrane lipids: phosphoglycerides (building blocks, structure of phosphatidylethanolamine and phosphatidylcholine). Sphingolipids: building blocks, structure of sphingosine, ceramide, general structure and functions of sphingomyelin, cerebroside and ganglioside. Lipid functions. Lipid aggregates: micelles, monolayers, bilayers and liposomes.

13

Practicals: 30 hours

Unit 1: Preparation of buffers and solutions: Concepts of molarity versus normality. Preparation of simple stock solutions of different molarities: sodium chloride, potassium permanganate, magnesium chloride solutions. Concept of pH. Role of buffers in biochemical reactions. Buffers of different pH ranges. Commonly used buffers in biochemical assays. Principle, calibration and use of pH meter. Preparation of two commonly used buffers: phosphate buffer, citrate buffer. Preparation of complex buffered stock solutions. Preparation of working solutions. **14**

Unit 2: Qualitative biochemical analyses: The use of pipettes and micropipettes. Cleaning and calibration of micropipettes. Principles and performance of qualitative tests for the detection of reducing and non-reducing sugars: Benedict's Test, Fehling's Test, Molisch Test; and starch: Iodine Test. Detection of lipids using Solubility Test, Osmic acid Test, Acrolein Test, Sudan III Test.

16

Suggested readings:

***Theory*:**

1. Lehninger Principles of Biochemistry by D.L. Nelson and M.M. Cox. 8th edition. W.H. Freeman and Company, UK. 2021.

2. Biochemistry by J.M. Berg, J.L.Tymoczko, G.J. Gatto, and L. Stryer. 9th edition. W.H. Freeman and Company, UK. 2019.

3. Biochemistry by T.A. Brown and S.N. Mukhopadhyay. 1st edition. Viva Books, India. 2018.

4. Fundamentals of Biochemistry by D. Voet, J.G. Voet and C.W. Pratt. 5th edition. John Wiley and Sons, UK. 2016.

Practicals:

1. Practical Biochemistry by R.C. Gupta and S. Bhargava. 5th edition. CBS Publishers and Distributors, India. 2018.

2. An Introduction to Practical Biochemistry by D. Plummer. 3rd edition. McGraw Hill Education, India. 2017.

3. Introduction to Practical Biochemistry (ebook) by G. Hegyi, J. Kardos, M. Kovacs, A. Malnasi-Csizmadia, L. Nyitray, G. Pal, L. Radnai, A. Remenyi and I. Venekei. Eotvos Lorand University. 2013.

4. Modern Experimental Biochemistry by Rodney Boyer. 3rd edition. Pearson, India. 2002.

Facilitating the achievement of Course Learning Outcomes:

S. No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks*
1.	Explain the principles of thermodynamics as applied to biological systems and will be able to comment on the rate constants and feasibility of biochemical reactions by calculating free energy changes	Classroom lectures on laws of thermodynamics, bioenergetics, numericals on standard free energy changes of coupled reactions	Problems on free energy change and standard free energy change and determination of equilibrium constant from data provided.
2.	Describe the structures and properties of various types of carbohydrates and will be able to relate the structures of simple and complex carbohydrates to their wide range of functions. Will gain knowledge of the role of sugars and their derivatives in formation of macromolecules /supramolecular complexes	Pictorial presentations of carbohydrates, mono, di-, and polysaccharides, including starch, glycogen, cellulose, and peptidoglycan. Use of flow charts for teaching structures and reactions.	Drawing the structures of carbohydrates. Multiple choice questions-type quiz on identification of anomers, epimers, enantiomers of sugars.

3.	Converse on the building block of lipids: fatty acids and their properties. Will acquire a clear understanding of the structures, properties and functions of storage and membrane lipids. Will learn of different types of lipid aggregates and their applications.	Lecture on lipids' structure, characteristic features and different types of "formations". Discussion on essential fatty acids and their significance in human nutrition.	Pictorial quiz on identification of biomolecules forming different types of lipids. Practice sessions for writing biochemical structures of different examples from lipid classes.
4.	Prepare buffers and solutions of different molarity and normality and will be adept in the use of fine weighing balances and pH meter.	Calibration and use of pH meter. Students in groups will prepare citrate buffers , phosphate buffer and acid of given molarities. Preparation of the stock solution of a given substance in group and its dilutions individually.	Students are required to write a report for all the exercises in a record book They will submit the practical's record on a specified date and will be assessed for it.
5.	Analyze foodstuff for their microchemical composition, and will be able to detect the presence of carbohydrates and fats in samples by performing qualitative tests. Will become familiar with the use of spectrophotometer.	Use of micropipettes and testing their accuracy Qualitative tests for the presence of reducing and non-reducing sugars, proteins, and lipids and resolving the composition of unknown samples.	May be given lab sheets with a write up leaving sections like observations and error analysis, for the students to complete. Students will perform and record in their lab books and assessed on the basis of their reporting. Students will be observed while performing lab work and will be assessed for their technical performance. They are encouraged to

			keep their lab books up to date which will be sampled a number of times during the semester.

***Assessment tasks are indicative and may vary.**

MICROB-GE-1

INTRODUCTION AND SCOPE OF MICROBIOLOGY

Marks: 100 (Theory = 50 marks
Practicals = 50 marks)

Duration: Theory = 30 hours (2 credits)
Practicals = 60 hours(2 credits)

Course objectives:

The main objective of the course is to give students an overview of three major themes: History and scope of Microbiology, microbial diversity (prokaryotes, eukaryotes, and viruses), and the role of microbes in human lives. Students will gain insights into how microorganisms affect the everyday lives of humans in both beneficial and harmful ways. Students will become familiar with the techniques used in isolation and cultivation of microorganisms, and will learn how to identify microorganisms in the laboratory.

Pre-requisite: None.

Course Learning Outcomes:

Upon successful completion of the course the student :

CO1: Will become familiar with the history of Microbiology, and understand how Microbiology developed as a distinct discipline of science during the golden era of microbiology. Will become familiar with some of the later developments of the 21st century.

CO2: Will acquire an understanding about the placement of microorganisms in the tree of life. Will know about key differences between prokaryotic and eukaryotic organisms. Will also be acquainted with structure of viruses, general characteristics and importance of algae, fungi and protozoa.

CO3: Will understand the importance of microbe-human interactions, becoming aware of microorganisms as agents of human diseases. Will become aware of the important role that microorganisms play in food, agriculture, industry, biofuel and in the clean-up of the environment.

CO4: Will become aware of good microbiological laboratory and safety practices, and be acquainted with the working of basic microbiological equipment routinely used in the laboratory. Will also be acquainted with the aseptic techniques used for culturing bacteria and fungi.

CO5: Will gain hands-on experience in isolation of bacteria and fungi from air and will be acquainted with staining techniques used for observing bacteria, algae and fungi. Will learn the use of compound microscope.

CO6: Will get acquainted with different shapes and arrangement of bacteria. Will be able to identify algae, fungi, protozoa using permanent slides/photographs. Will be able to understand the structure of viruses using electron micrographs.

Contents:

Theory: **30 hours**

Unit 1: History of Microbiology: Some key milestones in the field of microbiology: Contributions of Antonie van Leeuwenhoek. Controversy over spontaneous generation. Louis

Pasteur and concept of pasteurization. Robert Koch and germ theory of diseases, and concept of pure culture. Edward Jenner and cowpox immunization. Ivanovsky & Beijerinck and the discovery of viruses. Winogradsky and the development of soil microbiology. Golden era of Microbiology. **8**

Unit 2: Microbial Diversity: Position of microorganisms in the living world. Whittaker's five kingdom classification. Carl Woese's three domain classification. Detailed characteristics of prokaryotic and eukaryotic organisms with examples of *E. coli* (bacterium) and *Saccharomyces* (yeast). Acellular organisms: structure and genome of Tobacco mosaic virus, polio virus and bacteriophage T4. General characteristics, habitat and economic importance of algae, fungi and protozoa. **12**

Unit 3: The impact of microorganisms on humans: Causal organism and transmission of common human diseases: typhoid, tuberculosis, cholera, malaria, gastroenteritis, influenza. Microorganisms and their applications in agriculture: nitrogen fixers and mycorrhiza. Role of microorganisms in the environment: microbial remediation of pollutants. Applications of microorganisms in food and industry: fermented foods and probiotics, biofuel (biogas), antibiotics and enzymes. **10**

Practicals: 60 hours

Unit 4: Microbiological laboratory practices, and equipment: Good Microbiology laboratory practices and general safety measures while working with microbes. Physical and chemical hazards and immediate first aid. Principle, working and applications of instruments: autoclave, hot air oven, biosafety hood, incubator and light and compound microscope. Demonstration and performance of aseptic technique for culturing of bacteria and fungi. **24**

Unit 5: Cultivation, isolation and staining of cellular microorganisms: Study of aero microflora by exposing nutrient agar plate at different locations and comparing diversity on the basis of colony morphology. Demonstration of bacterial smear preparation from suitable sample/culture followed by Gram staining and observation under oil immersion objective. Preparation of stained temporary mounts of any one fungus (*Rhizopus*/ *Penicillium*) and any one alga (*Chlamydomonas*/ *Spirogyra*). **16**

Unit 6: Study of microorganisms: Study of shape and arrangement of following bacteria / bacterial structures using permanent slides: bacillus, coccus, spirillum and endospore. Study of vegetative and reproductive structures of following algae using permanent slides: *Chlamydomonas*, *Spirogyra* and *Polysiphonia*/Fucus. Study of vegetative and reproductive structures of following fungi and protozoa using permanent slides: Fungi: *Rhizopus, Penicillium* and *Agaricus*. Protozoa: *Amoeba*, *Paramecium, and Giardia*. Study of structure of the following viruses using electron micrographs: Tobacco mosaic virus, T4 bacteriophage and poliovirus. **20**

Suggested Reading:

1. Brock Biology of Microorganisms by M.T. Madigan,J. Aiyer,D. Buckley,W.Sattley and B. Stahl.16th edition. Pearson, USA. 2021.

2. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition. Pearson Education, USA. 2020.

3. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGrawHill Higher Education, USA. 2019.

4. Microbiology: An Introduction by G.J. Tortora, B.R. Funke,and C.L. Case. 13th edition. Pearson, USA. 2018.
5. Benson's Microbiological applications: Laboratory manual in general microbiology by A.E. Brown and H. Smith H. 15th edition. McGraw-Hill Education, USA. 2022.
6. Principles of Microbiology by R. M. Atlas. 2nd edition. W.M.T. Brown Publishers, USA.1997.
7. Microbiology by M. J. Pelczar, E. C. S. Chan and N. R. Krieg. 5th edition. McGraw Hill,USA. 1993.

Facilitating the Achievement Of Course Learning Objectives

Unit	Course learning outcomes	Teaching and learning activities	Assessment tasks*
1.	Will become familiar with the history of Microbiology, and understand how Microbiology developed as a distinct discipline of science during the golden era of microbiology. Will become familiar with some of the later developments of the 21st century.	Classroom lectures on the discovery of microorganisms, controversy over spontaneous generation, discoveries in the golden age of microbiology and latest developments in 21st century.	Identification of scientists through photographs related to development of Microbiology. Home assignment on historical developments that led to the development of germ theory of disease, pure culture technique and immunization.
2.	Will acquire an understanding about the placement of microorganisms in the tree of life. Will know about key differences between prokaryotic and eukaryotic organisms. Will also be acquainted with structure of viruses, general characteristics and importance of algae, fungi and protozoa.	Lecture on classification of living organism with emphasis on placement of microorganisms. Presentations on prokaryotic and eukaryotic microbial cell structure, structure of virus and economic importance of algae, fungi and protozoa.	Assignments on acellular and cellular microbes with examples; comparative account of prokaryotic and eukaryotic cell structure. Quiz on economic importance of algae, fungi and protozoa.
3.	Will understand the importance of microbe-human interactions, becoming aware of microorganisms as agents of human diseases. Will become	Presentations on common human diseases with their causative agents and mode of transmission. Interactive sessions on the role of different microorganisms in human welfare.	Quiz on common human diseases and their agents. Poster making on microorganisms used in making of foods, biofuels, enzymes,

	aware of the important role that microorganisms play in food, agriculture, industry, biofuel and in the clean-up of the environment.		biofertilizers, and antibiotics.
4	Will become aware of good microbiological laboratory and safety practices, and be acquainted with the working of basic microbiological equipment routinely used in the laboratory. Will also be acquainted with the aseptic techniques used for culturing bacteria and fungi.	Discussion on the importance of safety measures and good laboratory practices including disposal and proper handling of microbial cultures. Discussion and demonstration of working and applications of basic microbiological equipment. Demonstration of aseptic culture technique.	Making posters on good microbiology laboratory practices, comparative account of various biosafety levels (BSL1 to BSL4), safety in laboratories and immediate assistance in case of injury. Viva/quiz on functions of different components, and applications of instruments.
5.	Will gain hands-on experience in isolation of bacteria and fungi from air and will be acquainted with staining techniques used for observing bacteria, algae and fungi. Will learn the use of compound microscope.	Laboratory sessions for studying microbial flora of the air and practicing isolations by aseptic transfer of microorganisms. Demonstration of preparation of bacterial smears followed by Gram staining. Practical session for staining fungi and algae for observing under microscope.	Students are required to write a report for all the exercises in a record book. They will submit the practical record on a specified date and will be assessed for their laboratory work and the practical record work separately.
6.	Will get acquainted with different shapes and arrangement of bacteria. Will be able to identify algae, fungi, protozoa using permanent slides/photographs. Will be able to understand the structure of viruses using electron micrographs.	Observing permanent slides/photographs/ electron micrographs of various microorganisms for characteristic identifying features .	Recording salient features of various microorganisms alongwith well labelled diagrams in their practical files to be submitted at an informed time and assessing the record work.

***Assessment tasks are indicative and may vary.**

MICROB-GE-2

MICROBES IN HEALTH AND HYGIENE

Marks: 100 (Theory = 50 marks
Practicals = 50 marks)

Duration: Theory = 30 hours (2 credits)
Practicals = 60 hours(2 credits)

Course objectives:

The main objective of this course is to introduce the students to the role of microorganisms in human health. Students will be exposed to the importance of microbe-human interactions when learning about the human microbiome. They will become aware of common diseases caused by microorganisms and will develop an understanding of probiotics and their importance in human health. They will be introduced to bacteriophages and their application in treatment/control of bacterial infections.

Pre-requisite: Student should have studied Biology/ Biotechnology/ Biochemistry in 12th standard.

Course Learning Outcomes:

Upon successful completion of the course, the student:

CO1: Will be acquainted with the importance of the human microbiome including the benefits as well as possible harmful effects. They will have a fair knowledge of various types of microorganisms surviving on/in the human body.

CO2: Will have gained knowledge about the spectrum of diseases caused by bacteria, viruses, protozoa and fungi. They will be familiar with the methods of transmission and control of various diseases.

CO3: Will understand the role of probiotics in human health. They will have learnt about the characteristics of probiotic microorganisms and have a fair idea of prebiotics and synbiotics. They will also have an overview of bacteriophages and their role in therapy.

CO4: Will have hands-on training on isolation of microorganisms from skin and staining of microorganisms collected from oral cavity, and will be able to check the efficacy of the sanitizer and antimicrobial action of heavy metals.

CO5: Will become aware of various probiotic products available in the market and the organisms included in these products. They will receive hands-on training for evaluation of various probiotic products and microbial strains.

CO6: Will have a fair understanding of bacteriophage typing and will also have hands on training in the isolation of bacteriophages from sewage samples.

Contents:

Theory: **30 hours**

Unit 1: Role of microbiome in human health: Importance of human microbiome in health. Factors affecting the survival and colonization of microorganisms on various organs including skin, throat and upper respiratory tract, gastrointestinal tract and genitourinary tract. Understanding the human microbiome using animal model systems: *C. elegans*, mice, zebrafish. Strengths and weaknesses of using these systems for human microbiome studies. Technologies for assaying the human microbiome: direct observation methods, molecular

profiling techniques, sequencing methods, strengths and weaknesses of the technologies. **8**

Unit 2: Microorganisms in human diseases: A concise overview of aetiology, symptoms, transmission and control of some common diseases: bacterial (tuberculosis, cholera, typhoid, diphtheria), viral (rabies, hepatitis, zika, COVID , polio, AIDS), protozoan (malaria, kala azar) and fungal diseases (dermatophytoses, candidiasis, aspergillosis). **12**

Unit 3: Microbes for maintaining human health: Brief description and distinction between prebiotics, probiotics and synbiotics. Probiotics for maintaining human health: prerequisite characteristics of probiotic strains, common probiotic bacterial strains, modes of action of probiotics, probiotic supplementation for disease management. Bacteriophage therapy: concept and challenges. A brief account of bacteriophage therapy for various diseases. **10**

Practicals: **60 hours**

Unit 4. Study of human microflora: Isolation of microorganisms from skin by swab method using specific media: nutrient agar, mannitol salt agar, potato dextrose agar. Gram staining of bacterial isolates and lactophenol staining for fungal isolates. Gram staining of dental scrapings/plaques. Checking the efficacy of sanitizer on skin. study of the oligodynamic effect of metals on bacterial cultures. **Student group project**: multiple methods for sampling microbial biomass specimens for oral, skin, gut and respiratory microbiomes. **25**

Unit 5. Study of probiotics: Student group project: Conduction of a market survey to identify different probiotic products available in the market. Isolation and basic characterization of bacteria from probiotic products. Bacterial cell surface hydrophobicity (CSH) test to estimate bacterial adherence. Performance of acid and bile resistance test on bacterial strains. **25**

Unit 6. Bacteriophage isolation and typing: Principle, process and limitations of bacteriophage typing. Isolation of bacteriophages from sewage sample using double layer technique. **Student group project**: Phage therapy in India. **10**

Suggested Reading:

1. Brock Biology of Microorganisms by M.T. Madigan,J. Aiyer,D. Buckley,W.Sattley and D. Stahl.16th edition. Pearson, USA. 2021.
2. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGrawHill Higher Education, USA. 2019.
3. Textbook of Microbiology by R. Ananthanarayan and C.K.J. Paniker. 10th edition.Universities Press, India. 2017.
4. Jawetz, Melnick and Adelberg's Medical Microbiology by K.C. Carroll, S.A. Morse, T.A. Mietzner and S. Miller. 27th edition. McGraw Hill Education. 2016.
5. Microbiology: An Introduction by G.J. Tortora, B.R. Funke and C.L. Case. 9thedition.Pearson Education, USA. 2007.
6. Cappucino, J. and Sherman, N. (2014). Microbiology: A Laboratory Manual. 10th edition. Pearson Education, India.

7. Collee, J.G., Fraser, A.G., Marmion, B.P. and Simmons, A. (2007). Mackie and Mccartney Practical Medical Microbiology. Elsevier 14th edition 1996.

8. Randhawa, V.S., Mehta, G. and Sharma, K.B. (2009). Practicals and Viva in Medical Microbiology. 2nd edition. Elsevier, India.

9. Fuller, R. (2012). Probiotics: The Scientific Basis. Springer Netherlands.

10. Dhanasekaran, D. and Sankarnarayanan, A (2021). Advances in Probiotics, Microorganisms in Food and Health. Academic Press.

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1.	Will be acquainted with the importance of the human microbiome including the benefits as well as possible harmful effects. They will have a fair knowledge of various types of microorganisms surviving on/in the human body	Class room lectures on human microbiome. Pictorial representation of various organ systems with the corresponding microflora.	Test and quiz on human microbiome.
2.	Will have gained knowledge about the spectrum of diseases caused by bacteria, viruses, protozoa and fungi. They will be familiar with the methods of transmission and control of various diseases.	Class room lectures on the aetiology, symptoms, transmission and control of various diseases. Pictorial representation of various signs and symptoms of diseases.	Test and quiz on symptoms, transmission and control of various diseases. Match the following type quiz on disease and causative agent. Identification of disease based on photographs of specific disease presentation.
3.	Will understand the role of probiotics in human health. They will have learnt about the characteristics of probiotic microorganisms and have a fair idea of prebiotics and synbiotics. They will also have an overview of	Class room lectures and videos on probiotics and bacteriophages.	Test and quiz on role of probiotics, prebiotics, synbiotics and bacteriophages.

	bacteriophages and their role in therapy.		
4.	Will have hands-on training on isolation of microorganisms from skin and staining of microorganisms collected from oral cavity, and will be able to check the efficacy of the sanitizer and antimicrobial action of heavy metals.	Class room lecture and hands-on practical of isolation of bacteria from skin surface and staining of bacteria from oral cavity. Determination of sanitizer efficacy on skin.	Demonstration of practicals. Quiz on various aspects of practicals including principle, observations, result and precautions.
5.	Will become aware of various probiotic products available in the market and the organisms included in these products. They will receive hands-on training for evaluation of various probiotic products and microbial strains.	Online and offline survey of probiotic products and types of probiotic organisms. Practical demonstration of isolation of probiotics and study of various properties.	Demonstration of practicals. Quiz on various aspects of practicals including principle, observations, result and precautions.
6.	Will have a fair understanding of bacteriophage typing and will also have hands on training in the isolation of bacteriophages from sewage samples.	Classroom lecture on bacteriophage typing. Practical performance of isolation of bacteriophages from sewage.	Quiz on various aspects of practicals including principle, observations, result and precautions.

*** Assessment tasks are indicative and may vary.**

MICROB-GE-3

FOOD FERMENTATION AND PRESERVATION TECHNIQUES

Marks: 100 (Theory = 50 marks
Practicals = 50 marks)

Duration: Theory = 30 hours (2 credits)
Practicals = 60 hours(2 credits)

Course objectives:

The major objective of this paper is to develop clear understanding about the microorganisms important in food and various factors affecting their growth. The students will gain in depth knowledge about food fermentation, their benefits and the processes involved in production of fermented foods. The concept of probiotic, prebiotic and synbiotics will also be discussed. The course also deals with the principle and the techniques involved in processing and preservation of food substances. The students will also be trained and be given hands on training in various microbiological techniques involved in food fermentation and food preservation. The course on completion can open many career options.

Pre-requisite: Student should have studied Biology/ Biotechnology/ Biochemistry in 12th standard.

Course learning outcomes:

Upon successful completion of the course, the student:

CO1: Will be familiar with the microbes important in food, their morphological, cultural, and physiological characteristics, and factors influencing their growth

CO2: Will have got an overview of fermented foods and their health benefits. Also, will be acquainted with the microbes and their processes involved in production of fermented foods.

CO3: Will have learnt about the causes of food spoilage and be aware of different preservation techniques used to increase the shelf life of food products.

CO4: Will have gained hands on experience in isolating and characterizing microbes from food.

CO5: Will have become familiar with the principle of food fermentation by production of fermented foods in the laboratory.

CO6: Will have an insight into various microbiological and biochemical testing techniques used for assessing the efficacy of various food preservation techniques.

Contents:

Theory: **30 hours**

Unit 1: Microorganisms in Food Microbiology: Introduction to microorganisms important in foods: morphological, cultural and physiological characteristics of moulds (*Aspergillus, Rhizopus*), yeast (*Saccharomyces)*, and bacteria (*Lactobacillus, Acetobacter),* Factors affecting microbial growth in foods- intrinsic (pH, water activity, mechanical barriers and redox potential) and extrinsic (temperature, gaseous atmosphere). **6**

Unit 2: Food Fermentation: History, definition and benefits of fermented foods. Types of food

fermentations (acid-, yeast-, solid state-, oriental and indigenous fermented foods). Production and maintenance of microbial cultures involved in food fermentation, starter culture and its problems. Production of dairy (dahi, yoghurt, kefir, cheese) and non-dairy fermented foods (dosa, kanji, sauerkraut, tempeh, soy sauce), beverages (beer, wine) and concept of pre-, pro- and syn- biotics. **12**

Unit 3: Principles of food preservation: Definition and causes of food spoilage. Classification of food by ease of spoilage. General principles of food preservation. Preservation by low temperature: freezing & refrigeration. Preservation by high temperature: pasteurisation and canning. Preservation by moisture control: drying and dehydration. Preservation by radiation: Gamma, microwaves and UV rays. Preservation by added food preservatives: salt, sugar, benzoate, nitrite and nitrate, wood smoke, nisin. Preservation by developed preservatives, modified atmosphere packaging. **12**

Practicals: 60 hours

Unit 4: Isolation and characterisation of microbes important in food: Isolation and microscopic examination of fungi from a spoiled bread. Isolation of lactic acid bacteria from curd using MRS medium and microscopic characterisation by Gram's staining. Effect of different temperatures/ salt concentration on microbial growth. **24**

Unit 5: Food fermentation: Preparation of kefir using kefir grains/ fermented cabbage (sauerkraut). Viability test for yeast using methylene blue. Survey on the availability and usage of various probiotic foods from market. **12**

Unit 6: Food Preservation: Effect of blanching on food preservation. Incubation test for cans/ tetrapack to determine sterility. Alkaline phosphatase test to check efficiency of pasteurization of milk: principle, performance of the test with various pasteurized milk samples, evaluation of milk quality based on results obtained. Assessment of efficiency of sterilisation of milk: principle and performance of Turbidity Test and evaluation of milk quality based on obtained results. **24**

Suggested Readings:

1. Food processing and preservation by H. Naik and T. Amin. CRC Press. 2022.
2. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition. Pearson Education, USA. 2020.
3. Microbiology and Technology of fermented foods by R. Hutkins. 2nd edition. Wiley Blackwell, UK. 2019.
4. Food Microbiology by W.C. Frazier, D.C. Westhoff, and N.M. Vanitha. 5th edition. TataMcGraw-Hill Publishing Company Ltd, India. 2017.
5. Handbook of fermented functional foods by F. Edward. 2nd Edition. CRC press, UK. 2016.
6. FSSAI Manual of methods of analysis of foods. Food safety and standards Authority of India, Ministry of Health and Family Welfare, Government of India, 2015.
7. Advances in Fermented Foods and Beverages by W. Holzapfel. 1st edition. Woodhead Publishing, USA. 2014.

8. Handbook of food and beverage fermentation technology by Y. Hui, L. Meunier-Goddik, J. Josephsen, W. Nip and P. Stanfield. 1st edition. CRC Press, UK. 2004.

Facilitating the achievement of Course Learning Outcomes

S. No.	Course Learning Outcomes	Teaching and Learning Activity	Assessment Tasks
1.	Will be familiar with the microbes important in food, their morphological, cultural, and physiological characteristics, and factors influencing their growth	Interactive sessions with power point presentations on the morphological, cultural, and physiological characteristics of microbes important in food	Assignment and quiz on the characteristics of microbes associated with food and factors influencing their growth
2.	Will have got an overview of fermented foods and their health benefits. Also, will be acquainted with the microbes and their processes involved in production of fermented foods	Classroom lectures and detailed discussion on the fermentation process through flow charts, power point presentations and relevant online videos	Students to collect samples of various fermented foods available commercially and do market survey on their consumption. Class test / Assignment on MFC and types of starter cultures
3.	Will have learnt about the causes of food spoilage and be aware of different preservation techniques used to increase the shelf life of food products.	Teaching of various preservation techniques through power point presentations and online videos	Class tests, Quiz and MCQs on the various preservation methods
4.	Will have gained hands on experience in isolating and characterizing microbes from food.	Media preparation and sterilization, isolation & identification of various microbes in food. Also understanding the importance of various physical- chemical factors on growth	Drawing well labelled diagrams of microscopic observations of isolated fungi and bacteria from food
5.	Will have become familiar with the principle of food fermentation by production of fermented foods in the laboratory.	Hands on training on the laboratory preparation of fermented foods and survey on the consumption pattern of fermented foods	Compilation of report on the survey done by the students to understand the availability and acceptance of fermented foods
6.	Will have an insight into various microbiological and biochemical testing techniques used for assessing the efficacy of various food preservation techniques.	Laboratory training in processing and preservation protocols for different food products	Viva voce, multiple choice questions and spotting

***Assessment tasks listed here are indicative and may vary**

MICROB-GE-4

MICROBIAL QUALITY CONTROL AND TESTING

Marks: 100 (Theory = 50 marks
Practicals = 50 marks)

Duration: Theory = 30 hours (2 credits)
Practicals = 60 hours(2 credits)

Course objectives:

The main objective of the course is to underscore the importance of microbiological quality control in various sectors. Students will gain in-depth knowledge about criteria and procedures for safety in quality assurance in water, food and pharmaceutical sector. They will become proficient in various microbiological techniques used for quality testing of samples will be discussed. They will gain hands-on training in basic microbiological techniques used for quality testing.

Pre-requisite: Student should have studied Biology/ Biotechnology/ Biochemistry in 12th standard.

Course Learning Outcomes:

Upon successful completion of the course, the students:

CO1: Will have acquired knowledge about microbiological quality through Good Microbiological laboratory Practices (GMLP), biosafety levels, quality control of microbiological culture media, sterilization and antimicrobial susceptibility test.

CO2: Will have learnt methods to assess potability of drinking water, and become aware of Hazard analysis critical control point (HACCP) for food safety, as well as microbial limits in food and pharmaceutical products. Will be familiar with various microbiological standards and certifications by accredited certification bodies.

CO3: Will have gained insights into various microbiological, biochemical, molecular and immunological testing techniques used for assessing quality of drinking water and food products.

CO4: Will be capable of assessing the potability of water by performing various microbiological tests.

CO5: Will be capable of performing various biochemical and microbiological tests used to evaluate the quality of milk, packaged foods, pharmaceutical formulation and will gain knowledge about using phenol coefficient test for assessing quality of disinfectants.

CO6: Will learn to design HACCP plan for any food product manufacture like milk processing and packaging.

Contents:

Theory: **30 hours**

Unit 1: Safety practices and quality control in microbiology: Principles of Good microbiological laboratory practices (GMLP), Concept of biosafety levels (BSLs), Safety equipment and protective measures used in different categories of biosafety levels laboratories. Examples of microorganisms that are classified as BSL-1 to BSL-4. Quality control of microbiological culture media, sterilization, antimicrobial susceptibility test. **6**

Unit 2: Quality control and assurance in water, food and pharmaceutical sector: Water potability: criteria and procedures for quality assurance of drinking water, recommended quality control strains for water testing, recommendations of Environmental Protection Agency (EPA) for drinking water quality. Food safety and microbiology: overview of health hazards related to food, Hazard analysis of critical control point (HACCP) for food safety. Role of Codex Alimentarius Commission (CAC) in safety of food and agriculture products. BIS standards, FSSAI standards, ISO certification. Sterility testing of food and pharmaceutical products: importance and objectives, microbial limits. **10**

Unit 3: Microbial quality control tests: Collection and processing samples for testing. Detection of microorganisms and sample testing by culture and microscopic methods: direct microscopic counts (fluorescence-based), standard plate count method, selective media (*Salmonella-Shigella* agar, mannitol salt agar, EMB agar, McConkey agar), Bioburden testing, Most Probable Number (MPN), membrane filtration test, phenol coefficient test. Detection of microorganisms and sample testing by molecular methods: nucleic acid probes, PCR-based detection. Biosensors. Detection of microorganisms and sample testing by biochemical and immunological methods: Endotoxin testing by Limulus lysate test, pyrogen testing, rapid detection methods by Clot-on-Boiling Test **(**COB), Resazurin assay. **14**

Practicals: 60 hours

Unit 4: Water potability: Testing potability of water samples by standard procedures: Most Probable Number method (MPN) /presumptive test, confirmed test, completed test for faecal contamination: principles of the methods, performance of the tests with various water samples using differential and selective media, evaluation of the water quality based on the results obtained. Testing water potability by using standard kits. **20**

Unit 5: Food quality control and assurance: Assessment of the microbiological quality of raw versus pasteurized milk by Methylene Blue Dye Reduction Test (MBRT), evaluation and grading of milk quality based on the results obtained. Clot on boiling (COB) test of milk samples: principle, performance of the test with milk samples, and evaluation of milk quality based on results obtained. Sterility testing of canned food, tetra pack drinks and any pharmaceutical formulation (eye drops/ injection ampules) by either using the membrane filtration test or by standard plate count method. Detection of microorganisms in food samples through any one differential and selective medium. Demonstration of phenol coefficient test to evaluate efficacy of disinfectants using standard kits. **28**

Unit 6: HACCP: Student research study project: Designing of HACCP plan for milk processing and packaging or any other food product: product description, flowchart of production, assessing hazards and risks associated with different steps of production till consumption, identification of critical control points (CCP) and critical limits, suggestive procedures to monitor CCPs and corrective actions, effective record keeping to document the HACCP plan, and procedures for verification. **12**

Suggested Reading:

1. Analytical Food Microbiology: A Laboratory Manual by A.E. Yousef, J.G. Waite-Cusic and J.J. Perry. 2nd edition. Wiley Publishers, UK. 2022.

2. Laboratory Manual of Food Microbiology by N. Garg, K.L. Garg and K.G. Mukerji. Dreamtech Press, India. 2021.

3. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition.

Pearson Education, USA. 2020.

4. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGrawHill Higher Education, USA. 2019.

5. Food Safety & Quality Control by P. Mathur. Orient Black Swan Pvt. Ltd., India. 2018.

6. Manuals of methods of analysis of foods and water by Food safety and standards authority of India, Ministry of health and family welfare, Government of India, 2016.

7. Food Microbiology by W.C. Frazier, D.C. Westhoff, and N.M. Vanitha. 5th edition. TataMcGraw-Hill Publishing Company Ltd, India. 2013.

8. Handbook of Microbiological Quality Control in Pharmaceuticals and Medical Devices by R.M. Baird and S.P. Denver. 1st edition, CRC Press, U.K. 2000.

9. Microbiological Analysis of Food and Water: Guidelines for Quality Assurance by N.F. Lightfoot and E.A. Maier. Elsevier Science. 1998.

10. Essentials of Food Microbiology by J.H. Garbutt. 2nd edition. Hodder Arnold Publishers. 1997.

Facilitating the achievement of course learning objectives

Unit No.	Course learning outcomes	Teaching and learning activities	Assessment tasks*
1.	Will have acquired knowledge about microbiological quality through Good Microbiological laboratory Practices (GMLP), biosafety levels, quality control of microbiological culture media, sterilization and antimicrobial susceptibility test.	Classroom lectures on biosafety and Good Microbiological Laboratory Practices (GMLP).	Assignment on Biosafety, Good Microbiological Laboratory Practices (GMLP).
2.	Will have learnt methods to assess potability of drinking water, and become aware of Hazard analysis critical control point (HACCP) for food safety, as well as microbial limits in food and pharmaceutical products. Will be familiar with various microbiological standards and certifications by accredited certification	Detailed discussion on control, regulation and inspection measures of water and food products that ensure the consumer receives products of good microbiological quality.	Class test and quiz on quality assurance and control.

	bodies.		
3.	Will have gained insights into various microbiological, biochemical, molecular and immunological testing techniques used for assessing quality of drinking water and food products.	Teaching various microbiological examination techniques and tools through flow charts, powerpoint presentations and relevant online videos.	Quiz and MCQ's on various tests and techniques for microbiological assessment of water and food products.
4.	Will be capable of assessing the potability of water by performing various microbiological tests.	Hands on training to assess the quality of various water samples by using kits and by preparing and inoculating different differential, selective and biochemical media eg. Lactose fermentation broth, EMB agar, peptone water, glucose peptone broth and Simmons citrate agar.	Viva and quiz on various differential and selective media and biochemical tests.
5.	Will be capable of performing various biochemical and microbiological tests used to evaluate the quality of milk, packaged foods, pharmaceutical formulation and will gain knowledge about using phenol coefficient test for assessing quality of disinfectants.	Practical laboratory sessions on the evaluation of microbiological quality of milk, various packaged foods and pharmaceutical products. Insight into the testing of bactericidal efficacy of various disinfectants using phenol coefficient test.	A short report on the microbiological quality of packaged food items available in the college canteen.
6.	Will learn to design HACCP plan for any food product manufacture like milk processing and packaging.	Guiding students in the preparation of a document in accordance with the principles of HACCP system for a food chain from primary production to final consumption.	Posters/charts on HACCP plan.

***Assessment tasks are indicative and may vary.**

MICROB-GE-5

MICROBES IN ANIMAL HEALTH

Marks: 100 (Theory = 50 marks
Practicals = 50 marks)

Duration: Theory = 30 hours (2 credits)
Practicals = 60 hours(2 credits)

Course objectives:

The main objective of this course is to introduce the students to the importance of microorganisms in animal health. Students will learn about the interactions of microbes with various types of livestock and pet animals. Students will be introduced to various bacterial, fungal, viral and protozoan diseases of animals. They will be introduced to various types of microorganisms residing in rumen, and learn about various methods for obtaining blood, rumen fluid and milk samples from animals. They will be introduced to principles of various diagnostic methods used in lab diagnosis of animal infections. Students will learn about the vaccination schedule followed for cattle and poultry.

Pre-requisite: Student should have studied Biology/ Biotechnology/ Biochemistry in 12th standard.

Course Learning Outcomes:

Upon successful completion of the course, the student:

CO1: Will be acquainted with various types of livestock and pet animals, rumen microflora, and their advantages and disadvantages.

CO2: Will have gained knowledge about the spectrum of diseases caused by bacteria and fungi in animals, becoming familiar with the symptoms, transmission mode, treatment, prevention and control of various bacterial and fungal diseases.

CO3: Will understand the symptoms, transmission, treatment, prevention and control of various diseases caused by viruses and protozoa.

CO4: Will be familiar with various methods of sampling of blood and rumen fluid. Will have had hands-on training for the detection of mastitis by testing milk samples.

CO5: Will be aware of the principles of serological tests based on agglutination, precipitation, haemagglutination inhibition, ELISA and lateral flow assays for diagnosis of animal diseases/infection.

CO6: Will have a fair understanding of vaccination schedule followed for cattle, buffalo and poultry. They will learn the concept of differentiation between the vaccinated and infected animals.

Contents:

Theory: **30 hours**

Unit 1. Introduction to livestock and rumen microflora: A brief introduction of various types of livestock and pet animals: cattle, sheep, goat, dogs, cats and poultry. Different types of microbes in rumen along with their functions: archaebacteria (methanogens), bacteria, protozoa, fungi (cellulolytic and proteolytic). **8**

Unit 2. Bacterial and fungal diseases of animals: A concise overview of aetiological agent, symptoms, transmission, treatment, prevention and control of the following bacterial and fungal diseases: anthrax, brucellosis, mastitis, Johne's disease, campylobacteriosis, black quarter, haemorrhagic septicemia (HS), aspergillosis and mucormycosis. **12**

Unit 3. Viral and protozoan diseases of animals: An overview of aetiological agent, symptoms, transmission, treatment, prevention and control of following viral diseases: foot and mouth disease (FMD), rinderpest/PPR, blue tongue disease, avian influenza, canine distemper, rabies, babesiosis, theileriosis and trypanosomiasis. **10**

Practicals: 60 hours

Unit 4. Sampling methods for obtaining blood, rumen fluid and milk: Sampling of blood from cattle, sheep, goat, dog, cat, mice and poultry by virtual lab. Sampling of rumen fluid: syringe, rumenotomy by virtual lab/video. Sampling of milk: California mastitis test. **15**

Unit 5. Serological tests for diagnosis of infectious agent: Principle and working method of**:** Agglutination, precipitation, haemagglutination inhibition assay, ELISA, and Lateral flow assay for antigen detection. **30**

Unit 6. Vaccination of livestock animals: Concept of differentiation between infected and vaccinated animal (DIVA test) for FMD and brucellosis. **Student group project**: Research study and review of the vaccination schedules for cattle, buffalo and poultry. **15**

Suggested Reading:

1. Brock Biology of Microorganisms by M.T. Madigan, K.S. Bender, D.H. Buckley, W.M. Sattley and D.A. Stahl. 16th edition. Pearson Education, USA. 2021.
2. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition. Pearson Education, USA. 2020
3. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGrawHill Higher Education, USA. 2019.
4. Microbiology: An Introduction by G.J. Tortora, B.R. Funke,and C.L. Case. 13th edition. Pearson, USA. 2018.
5. Textbook of Microbiology by R. Ananthanarayan and C.K.J. Paniker. 10th edition.Universities Press, India. 2017.
6. Jawetz, Melnick and Adelberg's Medical Microbiology by K.C. Carroll, S.A. Morse, T.A.Mietzner and S. Miller. 27th edition. McGraw Hill Education. 2016.
7. Veterinary Microbiology by D. Scott McVey, Melissa Kennedy and M.M. Chengappa. 3rd edition. Wiley – Blackwell, USA. 2013.
8. Handbook of Good Dairy Husbandry Practices. National Dairy Development Board (NDDB).
9. Practicals and Viva in Medical Microbiology by V. Randhawa, G. Mehta and K. Sharma. 2nd edition. Elsevier, India. 2009.

10. Mackie and McCartney Practical Medical Microbiology by J. Collee, A. Fraser, B. Marmion and A. Simmons. 14th edition. Elsevier publications. 1996

Facilitating the achievement of Course Learning Outcomes

Unit no.	Course Learning Outcomes	Teaching and learning Activity	Assessment Tasks
1.	Will be acquainted with various types of livestock and pet animals, rumen microflora, and their advantages and disadvantages.	Class room lectures on livestock, pet animals and rumen microflora. Pictures of various animal breeds.	Test and quiz on livestock, pet animals and rumen microflora.
2.	Will have gained knowledge about the spectrum of diseases caused by bacteria and fungi in animals, becoming familiar with the symptoms, transmission mode, treatment, prevention and control of various bacterial and fungal diseases.	Class room lectures on the aetiology, symptoms, transmission, treatment, prevention and control of bacterial and fungal diseases in animals. Pictorial representation of various signs and symptoms of diseases.	Test and quiz on symptoms, transmission and control of various diseases. Match thefollowing type quizon disease and causative agent. Identification of disease based on photographs of specific disease presentation. MCQson causation of disease and prevention and control.
3.	Will understand the symptoms, transmission, treatment, prevention and control of various diseases caused by viruses and protozoa.	Class room lectures on the aetiology, symptoms, transmission, treatment, prevention and control of viral and protocoan diseases in animals. Pictorial representation of various signs and symptoms of diseases.	Test and quiz on symptoms, transmission and control of various diseases. Match thefollowing type quizon disease and causative agent. Identification of disease based on photographs of specific disease presentation.

			MCQson causation of disease and prevention and control.
4.	Will be familiar with various methods of sampling of blood and rumen fluid. Will have had hands-on training for the detection of mastitis by testing milk samples.	Various sampling methods through virtual lab / videos. Performance of California test for diagnosing mastitis.	Quiz on various aspects of the practicals. Recording of principle, observations, result and precautions in practical records.
5.	Will be aware of the principles of serological tests based on agglutination, precipitation, haemagglutination inhibition, ELISA and lateral flow assays for diagnosis of animal diseases/infection.	Various diagnostic methods through virtual lab / videos. Performance of ELISA/lateral flow assay.	Quiz on various aspects of the practicals. Recording of principle, observations, result and precautions in practical records
.6.	Will have a fair understanding of vaccination schedule followed for cattle, buffalo and poultry. They will learn the concept of differentiation between the vaccinated and infected animals.	Student group research study and group discussion on vaccination for various diseases and concept of differentiation of infectious and vaccinated animals (DIVA).	Quiz on various vaccines and concept of DIVA.

*** Assessment tasks are indicative and may vary.**

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DEPARTMENT OF MICROBIOLOGY

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DISCIPLINE SPECIFIC CORE COURSE – 4: Bacterial Diversity and Systematics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSC201: Bacterial Diversity and Systematics	4	3	0	1	Class XII pass with Biology/ Biotechnology/ Biochemistry	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is for students to acquire in-depth knowledge of bacterial cell structure and organization, cultivation methods and growth patterns, and reproduction.
- Further, the student gains insights into the vastness of bacterial diversity and its significance

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to describe the classification of bacteria based on their modes of nutrition, and the diverse physiological types of bacteria as determined by variable environmental factors.
- Student will be able to describe the fundamental concepts and terminology of taxonomic organization and parameters used in classifying bacteria, and the molecular analytic approaches used to classify diverse bacteria. Student will be avle to discuss about the use of rRNA analysis as a means of developing phylogenetic relationships.
- Student will be able to describe the major groups of archaea, their stand-out physiological and structural features, as well as their ecological niches and economic significance.
- Student will be able to discuss the major groups of eubacteria, including bacteria with special features such as mycoplasma, rickettsia, chlamydia and spirochetes.

- Student will be able to demonstrate bacteria count by serial dilution and identify different types of bacteria using various media.
- Student will be able to analyze bacteria microscopically using various staining methods.

SYLLABUS OF DSC-4

UNIT – I (1 Week)

Bacterial diversity based on nutritional and physiological factors: Classification of bacteria based on nutrition: lithotrophs, organotrophs, phototrophs, chemotrophs. Diversity based on physiological factors: solutes, pH, temperature, oxygen, pressure, radiation.

UNIT – II (4 Weeks)

Bacterial systematics: Definitions: Concepts of systematics, taxonomy, taxa, species, strains. Conventional and modern approaches to classification: Phenetic, phylogenetic, genotypic classification, evolutionary chronometers, rRNA oligonucleotide sequencing (ribotyping) and signature sequences, nucleic acid hybridization, genomic fingerprinting, MLSA, RFLP to study polyphasic bacterial taxonomy, FAME analysis

UNIT – III (4 Weeks)

Diversity of Archaea: General characteristics with reference to genera belonging to Crenarchaeota (*Sulfolobus*) and Euryarchaeota: Methanogens (*Methanobacterium)*, thermophiles (*Pyrococcus)*, acidophiles (*Picrophilus*) and halophiles (*Halobacterium*). Key features of other groups: Thaumarchaeota, Lokiarchaeota, Nanoarchaeota

UNIT – IV (6 Weeks)

Diversity of Eubacteria: Key features and significance of the following genera: Deeply Branching Bacteria**:** *Thermotoga, Deinococcus.* Proteobacteria: Classes and Types. Alphaproteobacteria: *Rhizobium, Ricketssia.* Betaproteobacteria: *Neisseria, Thiobacillus.* Gammaproteobacteria: *Escherichia, Yersinia.* Deltaproteobacteria: *Myxococcus* and *Bdellovibrio.* Epsilonproteobacteria: *Campylobacter, Helicobacter.* Zetaproteobacteria: *Mariprofundus ferrooxydans.* Non-Proteobacteria: Chlamydia, Spirochaetes. Gram Positive bacteria having genomes of low GC content: Firmicutes *Clostridium, Bacillus.* Tenericute *Mycoplasma.* Gram Positive bacteria having genomes of high GC content: *Mycobacterium, Streptomyces*

Practical component

UNIT 1: (5 Weeks)

Use of McConkey agar medium as a differential medium to distinguish between lactose- fermenting and lactose-nonfermenting gram negative bacteria. Enumeration of viable bacterial / CFU count using serial dilution and spread plate method/pour plate method.

Unit 2: (10 Weeks)

Bacterial staining methods: Use of light microscope to observe bacteria. Simple staining, Gram staining, Negative staining and Acid-fast staining (permanent mount). Endospore staining using malachite green. Observation of bacterial capsules by negative staining. Demonstration of bacterial motility by hanging drop method/flagellar staining.

Essential/recommended readings

Theory:

1. Brock Biology of Microorganisms by M.T. Madigan,J. Aiyer,D. Buckley,W.Sattley and D. Stahl.16th edition. Pearson, USA. 2021.
2. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGrawHill Higher Education, USA. 2019.
3. Microbiology: Principles and Explorations by J.G. Black and L.J. Black. 10th edition. Wiley, USA. 2019.
4. Microbiology: An Introduction by G.J. Tortora, B.R. Funke,and C.L. Case. 13th edition. Pearson, USA. 2018.
5. Principles of Microbiology by R. M. Atlas. 2nd edition. W.M.T. Brown Publishers, USA. 1997.
6. Microbiology by M. J. Pelczar, E. C. S. Chan and N. R. Krieg. 5th edition. McGraw Hill, USA. 1993.

Practicals:

1. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition. Pearson Education, USA. 2020.
2. Basic Lab Manual of Microbiology, Biochemistry and Molecular Biology by A. Ray and R. Mukherjee. Taurean Publisher, India. 2019.
3. Benson's Microbiological applications: Laboratory manual in general microbiology by A.E. Brown and H. Smith H. 15th edition. McGraw-Hill Education, USA. 2022.
4. Manual of Microbiology: Tools & Techniques by A.K. Sharma. 1st edition. Ane Books, India. 2007.

Suggestive readings

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 5: Biochemistry of Nucleic Acids and Proteins

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSC202: Biochemistry of Nucleic Acids and Proteins	4	3	0	1	Class XII pass with Biology/ Biotechnology/ Biochemistry	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to enable the students to develop a clear understanding of the structures and properties of biomolecules: proteins, lipids, carbohydrates and nucleic acids, and lays the foundation for a basic understanding of cellular processes.
- The students will gain an understanding of the principles of thermodynamics and bioenergetics, and will be introduced to the basic concepts of enzymes and enzyme kinetics.
- This course will empower the students with essential knowledge to support learning in subsequent courses offered in the program.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to describe the chemical structures of the building blocks of nucleic acids and the structures of the different types of DNA.
- Student will be able to describe the composition of proteins, and the structure and chemical properties of the different amino acids.
- Student will be able to describe the structural attributes of some classical proteins.
- Student will be able to analyze the constituents of an active enzyme, the interactions at enzyme active sites, and steady- state kinetics, allosteric regulation, and will be able to describe many different forms of enzymes found in living cells.

- Student will be able to analyze the structures of biomolecules using different types of models.
- Student will be able to analyze proteins qualitatively and quantitatively using different biochemical tests.

SYLLABUS OF DSC-5

UNIT – I (3 Weeks)
Nucleic acids: Introduction to importance of nucleic acids. Structures of purines and pyrimidines, nucleosides and nucleotides. Formation of DNA chains by phosphodiester bonds. Structure of DNA: the double helix. Types of DNA: A, B and Z. Properties of DNA. Types of RNA:rRNA, mRNA, tRNA

UNIT – II (3 Weeks)
Composition of Proteins: Introduction to the importance of proteins. Amino acids as building blocks: structures and properties of standard amino acids. Zwitterion, titration curves of amino acids, and determination of pKa and pI of monocarboxylic amino acid. Ninhydrin reaction. Essential amino acids, non-protein amino acids: beta-alanine, D-alanine and rare amino acids: selenocysteine, hydroxyproline. Oligopeptides: structure and functions of glutathione and aspartame

UNIT – III (2 Weeks)
Protein structure: primary, secondary (α helix, β sheets), super secondary (collagen), tertiary (myoglobin) and quaternary (haemoglobin). Structure of insulin

UNIT – IV (7 Weeks)
Enzymes: Concept of holoenzyme, coenzyme and apoenzyme. Cofactors: prosthetic group, Coenzyme: NAD, metal cofactors. Enzyme nomenclature and classification. Active site and activation energy. Lock and key hypothesis, induced fit hypothesis. Concept of steady state kinetics, Vmax and Km, significance of hyperbolic and double reciprocal plots. Enzyme unit, specific activity and turnover number. Temperature and pH effects on enzyme activity. Michaelis-Menten kinetics versus kinetics of allosteric enzymes. Competitive, non-competitive and uncompetitive enzyme inhibition. Allosteric enzymes: Phosphofructokinase. Multienzyme complex: pyruvate dehydrogenase. Isozyme: lactate dehydrogenase. RNA as enzymes: Hammerhead ribozyme

Practical component

UNIT 1: (5 Weeks)
Study of biomolecules with the help of models: The use of different types of models for visualizing molecular structures of biomolecules: Space filling models, Ball and stick models, Ribbon Models. Study of protein secondary and tertiary structures with the help of photographs/ models: collagen, myoglobin, hemoglobin.

Unit 2: (10 Weeks)

Qualitative and quantitative analysis of proteins: Qualitative analysis of proteins using Xanthoproteic Test, Millon's Test, Biuret Test, Ninhydrin Test. Quantitative estimation of proteins by Lowry's method using bovine serum albumin as the standard. Demonstration of enzyme activity (amylase / urease / catalase) and effect of temperature, pH and heavy metal salt on activity.

Essential/recommended readings

Theory:

1. Lehninger Principles of Biochemistry by D.L. Nelson and M.M. Cox. 8th edition. W.H. Freeman and Company, UK. 2021.
2. Biochemistry by J.M. Berg, J.L.Tymoczko, G.J. Gatto, and L. Stryer. 9th edition. W.H. Freeman and Company, UK. 2019.
3. Biochemistry by T.A. Brown and S.N. Mukhopadhyay. 1st edition. Viva Books, India. 2018.
4. Fundamentals of Biochemistry by D. Voet, J.G. Voet and C.W. Pratt. 5th edition. John Wiley and Sons, UK. 2016.

Practicals:

1. Practical Biochemistry by R.C. Gupta and S. Bhargava. 5th edition. CBS Publishers and Distributors, India. 2018.
2. An Introduction to Practical Biochemistry by D. Plummer. 3rd edition. McGraw Hill Education, India. 2017.
3. Introduction to Practical Biochemistry (ebook) by G. Hegyi, J. Kardos, M. Kovacs, A. Malnasi-Csizmadia, L. Nyitray, G. Pal, L. Radnai, A. Remenyi and I. Venekei. Eotvos Lorand University. 2013.
4. Modern Experimental Biochemistry by Rodney Boyer.3rd edition. Pearson, India. 2002.

Suggestive readings

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time. **CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

DISCIPLINE SPECIFIC CORE COURSE – 6: Food and Dairy Microbiology

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSC203: Food and Dairy Microbiology	4	3	0	1	Class XII pass with Biology/ Biotechnology/ Biochemistry	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to familiarise students with the importance of microorganisms in food spoilage as well as in preparation of certain foods, and to acquaint the students with quality control and safety indices used in the food industry

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to evaluate the factors governing microbial growth in foods and sources of food contamination.
- Student will be able to discuss the factors that govern spoilage of some common foods due to microbial activity.
- Student will be able to describe various physical and chemical methods used for food preservation.
- Student will be able to analyse the role of microorganisms in the production of fermented dairy and non-dairy food products. Will understand the health benefits of prebiotics, probiotics and synbiotics.
- Student will be able to discuss on the common food-borne diseases and preventive measures to be used, as well as methods for detection of food-borne pathogens.
- Student will be able to determine the importance of quality control in the food industry and describe various indices being used to measure quality and safety in the food industry.

SYLLABUS OF DSC-6

UNIT – I (3 Weeks)

Foods as a substrate for microorganisms: Natural microflora and contamination sources of foods. Factors impacting growth and survival of microbes in foods. Intrinsic : pH, moisture content, nutrient availability, Eh values, antimicrobial substances and biological structures. Extrinsic: temperature, relative humidity and gaseous storage. Spoilage of foods by microorganisms: Factors responsible for food spoilage. Non- perishable, -semi perishable and - highly perishable foods. Spoilage of vegetables, fruits, meat, eggs, milk, butter, bread, and canned foods

UNIT – II (3 Weeks)

Food preservation methods: Physical methods of food preservation: Temperature control (low: refrigeration, freezing; high: boiling, blanching, pasteurization, UHT, aseptic packaging). Canning: home and commercial. Dehydration: natural drying, artificial drying, freeze drying, smoking and tying of water molecules, reduced water activity products. Irradiation: radicidation, radurization, radappertization. Hydrostatic pressure, high voltage pulse, microwave processing. Chemicals used in food preservation: salt, sugar, organic acids, SO2, nitrites and nitrates, ethylene oxide, antibiotics and bacteriocins

UNIT – III (3 Weeks)

Fermented dairy and non-dairy foods: Starter cultures. Fermented foods: yogurt, acidophilus milk, kumiss, kefir, dahi, cheese, bread, dosa, kanji, sauerkraut, soy sauce, tempeh, and fermented meat (sausages). Concept, health benefits and limitations of prebiotics, probiotics and synbiotics. Selection criteria for probiotic. Probiotic foods available in the market.

UNIT – IV (4 Weeks)

Food intoxications, food infections and detection of food borne pathogens. Causative agents, foods involved, symptoms and preventive measures in food-borne diseases caused by Clostridium botulinum, Shigella (bacillary dysentery), Vibrio cholerae, Escherichia coli, Yersinia enterocolitica, Salmonella (food infection), Entamoeba histolytica. Mycotoxins: aflatoxins (Aspergillus). Detection of food-borne pathogens: culture-based as well as rapid detection methods

UNIT – V (2 Weeks)

Quality control in the Food Industry: Total Quality Management (TQM): concepts and approaches. Hazard Analysis of Critical Control Point (HACCP) for food safety: principles and limitations. Indices of food quality (IFQ): FSSAI standard, ISO certification.

Practical component

UNIT 1: (7.5 Weeks)

Microbial spoilage of food and fermented foods:

Isolation and identification of spoilage fungi from various spoiled vegetables/ fruits: collection of spoilt food samples, point inoculation on suitable media, preparation of temporary mounts, and microscopic observations. Isolation and identification of spoilage fungi from spoiled breads using similar methods. Comparison of the fungi identified in the two categories of foods. Fermented

foods: Production of fermented foods using starter cultures and normal microflora of food. Preparation of yogurt / dahi. Preparation of sauerkraut / kanji. Preparation of buttermilk and butter. Preparation of kefir using kefir grains. Student research study project: unusual fermented foods from India and around the world.

Unit 2: (7.5 Weeks)

Food Quality Control :

Methylene Blue Dye Reduction Test (MBRT) to assess the microbiological quality of raw versus pasteurized milk: principle of the method, performance of the test with various samples of milk, evaluation and grading of milk quality based on the results obtained. Evaluation of milk quality by assessing its bacterial load using the standard plate count with serial dilutions of the milk. Clot on boiling (COB) test of milk samples: principle, performance of the test with milk samples, and evaluation of milk quality based on results obtained. Alkaline phosphatase test to check efficiency of pasteurization of milk: principle, performance of the test with various pasteurized milk samples, evaluation of milk quality based on results obtained.

Essential/recommended readings

Theory:

1. Antimicrobials in Foods edited by P.M. Davidson, T.M. Taylor, and J.R.D. David. 4th edition. CRC Press, UK. 2020.
2. Food Microbiology by W.M. Foster. CBS Publishers & Distributors Pvt. Ltd. 2020
3. Food Microbiology by W.C. Frazier, D.C. Westhoff, and N.M. Vanitha. 5th edition. TataMcGraw-Hill Publishing Company Ltd, India. 2017.
4. Food Microbiology by M.R. Adams, M.O. Moss and P. McClure. 4th edition. Royal Society of Chemistry, UK. 2015.
5. Fundamental Food Microbiology by B. Ray and A. Bhunia. 5th edition. CRC Press. 2013.
6. Basic Food Microbiology by G.J Banwart. 2nd edition. CBS Publishers and Distributors, India. 2004.
7. Modern Food Microbiology by J.M. Jay, M.J. Loessner and D.A. Golden. 7th edition. Springer, Switzerland. 2005.
8. The Microbiological Safety and Quality of Foods. Vol. 1-2 by B.M. Lund, T.C. Baird-Parker,and G.W. Gould. ASPEN Publication, USA. 2000.

Practicals:

1. Analytical Food Microbiology: A Laboratory Manual by A.E. Yousef, J.G. Waite-Cusic and J.J. Perry. 2nd Edition. Wiley Publishers, UK. 2022.
2. Laboratory Manual of Food Microbiology by N. Garg, K.L. Garg and K.G. Mukerji. Dreamtech Press, India. 2021.
3. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition. Pearson Education, USA. 2020.
4. Laboratory manual of Microbiology and Biotechnology by K.R. Aneja. 2nd edition. Scientific International Pvt. Ltd., Delhi. 2018.

Suggestive readings

Note: **Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.**

COMMON POOL OF GENERIC ELECTIVES (GE) COURSES OFFERED BY THE DEPARTMENTS

GENERIC ELECTIVES (GE-6: MICROBES IN ENVIRONMENTAL MANAGEMENT)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
MICROB-GE6: MICROBES IN ENVIRONMENTAL MANAGEMENT	4	2	0	2	None	NIL	Microbiology

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of the course is for students to appreciate how various microorganisms are bestowed with the capacity to modulate the environment.
- Students will get acquainted with the role of microbes in biodegradation, biogeochemical cycling, and production of biofuels.
- They will become aware of environmental problems and how microorganisms are used to manage these problems.
- This course will motivate them to think of novel ways to solve various environmental issues, including newer challenges such as e-waste management and plastic degradation using suitable microbes

Learning outcomes

The Learning Outcomes of this course are as follows:

- The student will be able to recall the importance of microbes in any ecosystem with reference to nutrient cycling/ biogeochemical cycling, and biofuels and the role of microbes in mineral recovery.
- The student will be able to describe BOD, COD and various methods of waste treatment (solid and liquid) utilizing diverse microorganisms.

- The student will be able to describe microbial bioremediation, including petroleum products, microbial degradation of pesticides, plastics and e-waste management for a cleaner environment.
- The student will be able to describe the concept of potability of water and demonstrate various tests to check the potability of given water samples.
- The student will be able to demonstrate isolation of microorganisms with special and unique properties from natural reservoirs of soil and landfills etc. and analyse how they keep reclaiming and rejuvenating our environment.
- The student will be able to demonstrate the use of conventional methods with innovative solutions to preserve and enhance environmental sustainability.

SYLLABUS OF MICROB-GE6

UNIT – I (5 Weeks)
Role of microbes in biodegradation, biofuels and bioleaching: Role of microbes in biodegradation and maintaining a continuous supply of nutrients like carbon, nitrogen (nitrogen fixation, ammonification and denitrification) and phosphorus in the ecosystem. Microbes as sources of Biofuels: bioethanol, algal biofuels, biogas, microbes in mineral recovery (iron, gold).

UNIT – II (6 Weeks)
Microbes in waste management: Sources and types of solid waste, sanitary landfill, composting. Liquid waste management: composition and strength of sewage (BOD and COD). Primary, secondary (aerobic: Oxidation pond, Trickling filter, Activated sludge process; anaerobic: Septic tank, Imhoff tank, anaerobic sludge digestor); and tertiary sewage treatment

UNIT – III (4 Weeks)
Microbial bioremediation: Bioremediation of contaminated soils (heavy metals and petroleum) and marine pollutants. Microbial degradation of pesticides (2,4-D and 2,4,5-T). Role of microbes in e-waste management and plastic degradation

Practical component –

UNIT – 1 (5 Weeks)
Determination of water potability: Water potability, Safety standards of drinking (potable) water. Methods to determine potability of water samples, standard qualitative procedure - presumptive test/MPN test, confirmed and completed tests for faecal coliforms; membrane filtration technique and Presence/Absence tests for coliforms using rapid detection kit

UNIT – 2 (6 Weeks)
Isolation of microbes important in environment management: Detection of starch/ cellulose-degrading and dye (malachite green/ crystal violet/ methylene blue) decolorising microorganisms from the soil. Isolation of heavy metal-accumulating

(copper/ nickel/ zinc/ cobalt/ aluminium) microorganisms from soil, and plastic-degrading microbes from landfills

UNIT – 3 (4 Weeks)

Preparation of compost using composting pits on college premises or elsewhere. Student Idea Presentation on environment protection. Visit to a wastewater treatment plant/solid waste treatment site. Understanding eutrophication and algal blooms with the help of pictures

Essential/recommended readings

1. Brock Biology of Microorganisms by M.T. Madigan,J. Aiyer,D. Buckley,W.Sattley and D. Stahl.16th edition. Pearson, USA. 2021.
2. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGrawHill Higher Education, USA. 2019.
3. Soil Microbiology by N.S. Subba Rao. 5th edition. Medtech, India. 2017.
4. Environmental Microbiology edited by I.L. Pepper, C.P. Gerba, T.J. Gentry. 3rd edition.Academic Press, USA. 2014.
5. Advances in Applied Bioremediation edited by A. Singh, R.C. Kuhad and O. P. Ward.Springer-Verlag, Germany. 2009.
6. Microbial Ecology: Fundamentals and Applications by R.M. Atlas, R. Bartha. 4th edition.Benjamin Cummings, USA. 2000.
7. An Introduction to Soil Microbiology by A. Martin. 2nd edition. John Wiley and Sons Co, UK. 1991.

Suggestive readings (if any)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-7: MICROBES IN INFECTIOUS DISEASES)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
MICROB-GE7: **MICROBES IN INFECTIOUS DISEASES**	**4**	**2**	**0**	**2**	**None**	**NIL**	**Microbiology**

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to gives students of other disciplines an overview of the fundamentals of principles of immunology, infection and disease.
- The students will become aware of the whole spectrum of infectious diseases caused by different classes of microbes.
- They will be become familiar with methods of disease diagnosis, the identification of the causative microbe and the latest immunological techniques.

Learning outcomes

The Learning Outcomes of this course are as follows:

- The student will be able to describe the basic concepts associated with infectious diseases and the principles and types of infection.
- The student will be able to describe different immune organs, immune cells, and their functions, and discuss the role of antigens and antibodies in fighting infection.
- The student will be able to describe different types of microbial diseases, their symptoms, and mode of transmission.
- The student will be able to demonstrate the complete blood count (TLC and DLC), and able to identify the human blood groups and different immune cells.
- The student will be able to describe about the different selective and differential media for culturing bacteria, and the principle and working of PCR-based tests for disease diagnosis.
- The student will be able to identify pathogenic bacteria by performing biochemical tests.

SYLLABUS OF MICROB-GE7

UNIT – I (3 Weeks)

Introduction to basic concepts of infection and disease: Infection, colonization, pathogenicity, virulence and its determinants (adhesion, enzymes, toxins - exotoxins and endotoxins), transmission (direct and indirect) of infectious diseases. Types of infections (acute, latent, chronic), opportunistic and nosocomial infections. Reservoir and source of infection.

UNIT – II (6 Weeks)

Basic principles of immunology: Basic concepts of innate and adaptive immunity. Cells and organs of the immune system. Characteristics of antigen (foreignness, molecular size and heterogeneity), haptens, adjuvant. Structure, types and functions of antibodies. Cell mediated immunity. Primary and secondary immune response. Principles of immunization and types of vaccines

UNIT – III (6 Weeks)

Infectious diseases and their transmission: Symptoms and mode of transmission of diseases. Bacterial : tuberculosis, tetanus, anthrax. Viral: chicken pox, measles, mumps, polio, COVID-19, AIDS, dengue. Fungal: athlete's foot, histoplasmosis, candidiasis. Protozoan: malaria, amoebiasis

Practical component –

UNIT – 1 (5 Weeks)

Immunological techniques: Use of the haemocytometer. Analyzing total leucocyte count and differential leukocyte count in blood sample: determining percent count neutrophils, lymphocytes, eosinophils, basophils and monocytes in a blood smear. Identification of human blood groups and different immune cells

UNIT – 2 (5 Weeks)

Culturing of microorganisms and diagnosis: Use of various selective and differential media for culturing and identification of bacteria: mannitol salt agar, deoxycholate citrate agar / Salmonella Shigella (SS) agar, MacConkey / EMB Agar. Use of PCR based techniques to identify the infectious agent. Student group project: Different methods used to diagnose the following diseases: COVID19, tuberculosis

UNIT – 3 (5 Weeks)

Biochemical tests for identifying bacteria: Bacterial identification based on morphological features: Gram staining, capsule, endospore and motility characteristics. Bacterial identification based on biochemical characteristics: IMViC (Indole test, Methyl Red test, Voges-Proskauer test, Citrate test), Triple Sugar Iron (TSI) test, and catalase test. Kit based identification of a microbial pathogen.

Essential/recommended readings

1. Textbook of Microbiology by R. Ananthanarayan and C.K.J. Paniker. 11th edition. Universities Press, India. 2020.

2. Prescott's Microbiology by J. M. Willey, K. Sandman, K. and D. Wood. 11th edition. McGraw Hill Higher Education, USA. 2019
3. Basic Immunology: Functions and Disorders of the Immune System by A. K. Abbas, A. H. Lichtman, S. Pillai. 6th edition. Elsevier, India. 2019.
4. Kuby Immunology by J. Punt, S. Stranford, P. Jones, and J. Owen. 8th edition. W.H. Freeman and Company, USA. 2018.
5. Jawetz, Melnick and Adelberg's Medical Microbiology by K.C. Carroll, S. A. Morse, T.A. Mietzner, and S. Miller. 28th edition. McGraw Hill Education, USA. 2016. Immunology by C. Richard and S. Geoffrey. 6th edition. Wiley- Blackwell Scientific Publication, UK. 2009.

Suggestive readings (if any)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-8: APPLICATIONS OF MICROBES IN BIOTECHNOLOGY)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
MICROB-GE8: APPLICATIONS OF MICROBES IN BIOTECHNOLOGY	4	2	0	2	None	NIL	Microbiology

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to provide the students a clear understanding on the biotechnological potential of microorganisms in production of important industrial products like amino acids, antibiotics, vitamins, biopolysaccharides, bioplastics, pharmaceutical products, high fructose corn syrup, biofertilizers, biopesticides, transgenic plants, biofuels and biogas.
- They will also learn about the use of microorganisms for detoxification of industrial effluents, biogas production and extraction of metals from even low-grade ores.

Learning outcomes

The Learning Outcomes of this course are as follows:

- The student will be able to describe the concept of genetic manipulation of microbes by metabolic engineering and the production of important microbial products of immense industrial and medical/therapeutic value.
- The student will be able to describe the use of microbes in agricultural biotechnology for the formulation of biopesticides, biofertilizers, transgenic plants with desirable traits like disease resistance etc; and the importance of microorganisms in environmental management and biofuels production.
- The student will be able to demonstrate whole cell and enzyme immobilization techniques with strategies of dye decolorization using microorganisms.
- The student will be able to demonstrate the isolation and screening of enzyme producers from soil and symbiotic & asymbiotic nitrogen fixers.

- The student will be able to collect, analyse and interpret data on commercially available microbial products; and describe the cultivation and importance of edible mushrooms as well as single cell proteins.

SYLLABUS OF MICROB-GE8

UNIT – I (2 Weeks)
General Microbial Biotechnology: Scope of microbial biotechnology in agriculture, healthcare, environmental management, genomics, and proteomics, with suitable examples. Microbes commonly used in microbial biotechnology: viruses, bacteria, fungi. Relevance of natural, laboratory-selected mutant and genetically engineered microbes (GEMs), primary and secondary metabolites, metabolic engineering.

UNIT – II (6 Weeks)
Biotechnological potential of microbes in industry and medicine: Production and applications of microbial products: amino acids (glutamic acid), antibiotics (streptomycin), vitamins (vitamin B12), polysaccharide (xanthan gum), bioplastic (PHB), high fructose corn syrup using immobilized microbial enzyme glucose isomerase. Production and applications of important medicinal products: Insulin, recombinant vaccine (Covishield) and Microbial biosensor (glucose oxidase), gene therapy for SCID in humans using virus

UNIT – III (7 Weeks)
Agricultural and Environmental Biotechnology: Biofertilizers and biopesticides in agriculture: definition, classification with examples, advantages and disadvantages. Fertilizers from agricultural waste. Development of transgenic crops with important traits such as resistance to insects and viruses, herbicide resistance and environmental stress (drought and frost). Brief description of Bt cotton and Golden rice. Biofuel production from lignocellulosic waste and algal biomass, biogas (methane and hydrogen) production using microbes. Role of microbes in bioremediation (superbug, oilzapper, concentration of uranium from waste using bacteria). Biodegradation of xenobiotics (types of xenobiotics, hazards from xenobiotics, origin of microbial capacity to degrade xenobiotics and suitable examples) and microbial mining (mineral recovery of metals by bioleaching)

Practical component –

UNIT – 1 (4 Weeks)
Microbial enzyme immobilization and dye degradation: Performing yeast cell immobilization and enzyme immobilization in suitable polymers by calcium alginate method, studying the activity and reuse of the immobilized enzyme for recycling purpose, observing dye decolorization/degradation using bacteria or fungi.

UNIT – 2 (6 Weeks)
Enzymes and microbes from soil: Screening of soil samples for isolation of hydrolytic enzymes: protease, lipase, cellulase, xylanase (any two) producing microorganisms using plate assay, isolation of symbiotic nitrogen fixer: Rhizobium from root nodules, isolation of asymbiotic nitrogen fixers from soil: Azotobacter and Azospirillum

UNIT – 3 (5 Weeks)

Microbial products: Student group project: Conducting a market survey to identify any five popular microbial products and working to identify the microbe(s) involved in its production and the method of its preparation. Study of mushroom cultivation: importance, types of edible mushrooms and their cultivation, introduction to medicinal mushrooms. Single cell protein from algae Spirulina & Chlorella: medicinal importance, advantages, disadvantages and production strategies.

Essential/recommended readings

1. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGrawHill Higher Education, USA. 2019.
2. Biotechnology: A Textbook of Industrial Microbiology by W. Crueger, A. Crueger and K.R.Aneja. 3rd edition. Medtech Publisher, India. 2017.
3. Principles of Fermentation Technology by P.F. Stanbury, A.Whitaker and S.J. Hall. 3rdedition. Elsevier Science Ltd, Netherlands. 2016.
4. A Textbook of Biotechnology by R.C. Dubey. 5th edition. S. Chand and Co, India. 2014.
5. Molecular Biotechnology by B.R. Glick, J.J. Pasternak and C.L. Patten. 4th edition, ASMPress, USA. 2009.
6. Microbial Biotechnology by A.N. Glazer and H. Nikaido. 2nd edition. Cambridge UniversityPress, UK. 2007.
7. Elements of Biotechnology by P.K. Gupta. 2nd edition. Rastogi Publications, India. 2009.
8. Basic Biotechnology by C. Ratledge and B. Kristiansen. 3rd edition. Cambridge UniversityPress, UK. 2006.
9. Modern Industrial Microbiology and Biotechnology by Naduka Okafor. Science Publishers, USA. 2007.
10. Manual of Industrial Microbiology and Biotechnology by A.L. Demain, J.E. Davies and R.M. Atlas. 2nd edition. ASM Press, USA. 1999.

Suggestive readings (if any)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-9: FUNDAMENTALS OF AGRICULTURAL MICROBIOLOGY)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
MICROB-GE9: FUNDAMENTALS OF AGRICULTURAL MICROBIOLOGY	4	2	0	2	None	NIL	Microbiology

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this paper is to develop clear understanding of the role of soil and soil microbes in agriculture.
- The student will get an overview of plant microbe interaction and the role of microbes in nutrient cycles and their importance in agriculture.
- The students will have an in- depth knowledge of biofertilizers, composting and their importance for improving crop productivity.
- They will get familiarized with the significance of biocontrol agents and organic farming.

Learning outcomes

The Learning Outcomes of this course are as follows:

- The student will be able to describe the overview of soil and its characteristics and, the important microorganisms involved in mineralization of essential nutrients present in the soil and their significance in agriculture. Students will be able to describe various plant-microbe interactions including symbiotic and non-symbiotic associations.
- The student will be able to describe various microorganisms acting as biofertilizers including bacterial, fungal and algal biofertilizers. Students will be able to recognize the benefits of biofertilizers as compared to chemical fertilizers in terms of increased crop productivity and mass culturing of biofertilizers. Students will be able to describe various aspects of composting.
- The student will be able to discuss types and applications of bacterial and fungal biocontrol agents in agriculture and importance of organic farming.

- The student will be able to determine soil type, texture and its characteristics. Students will be able to describe the microbial interactions with plants, the different stages of nodules in leguminous plant roots and nodule forming bacteria under microscope. Student will be able to identify the stages of Mycorrhizal colonization through pictures.
- The student will be able to describe soil microbiology and microbial ecology, including the types of organisms living in soil. Students will be able to demonstrate the presence of microorganisms in soil by CO2 evolution and enzyme activity.
- The student will be able to describe the recycling of organic matter for an easy and cheap way to make compost to enhance soil quality. They will also know about the antagonistic potential of Trichoderma spp. as biological control agent against other fungi.

SYLLABUS OF MICROB-GE9

UNIT – I (6 Weeks)

Microbes and soil fertility: Study of soil properties and microbial interactions: Study of soil types and its texture with the help of Sieve method/Mason jar method. Hands-on analysis of different soil characteristics - pH, moisture content, water holding capacity, percolation, capillary action of a soil sample. Isolation of phylloplane microflora on nutrient agar and potato dextrose agar by leaf impression technique. Demonstration of stages of nodule formation in leguminous plant with the help of photographs. Slide preparation of crushed nodule to observe nodule forming bacteria. Study of mycorrhizal association through pictures

UNIT – II (6 Weeks)

Biofertilizers and composting: Introduction and scope of biofertilizers. Types, characteristics, mass production and methods of applications of the following: Bacterial biofertilizers: *Rhizobium*, *Azotobacter*, *Azospirillum*. Algal fertilizer: blue green algae, Azolla- Anabaena. Fungal biofertilizers: mycorrhiza. Quality testing of biofertilizers (ISI standards). Role of microbes in organic matter decomposition and different methods of composting.

UNIT – III (3 Weeks)

Biocontrol agents and organic farming: Importance, potential and types of biocontrol agents. Application of *Trichoderma spp*. and *Bacillus thuringiensis* as biocontrol agents in agriculture. Concept of organic farming, types, methods and advantages.

Practical component –

UNIT – 1 (7 Weeks)

Study of soil properties and microbial interactions: Study of soil types and its texture with the help of Sieve method/Mason jar method. Hands-on analysis of different soil characteristics - pH, moisture content, water holding capacity, percolation, capillary action of a soil sample. Isolation of phylloplane microflora on nutrient agar and potato dextrose agar by leaf impression technique. Demonstration of stages of

nodule formation in leguminous plant with the help of photographs. Slide preparation of crushed nodule to observe nodule forming bacteria. Study of mycorrhizal association through pictures.

UNIT – 2 (5 Weeks)

Evaluation of microbial activity in soil: Study of microbial activity in soil by CO2 evolution: determination of CO2 by trapping it in alkali solution and its estimation by titration. Detection of microbes in soil by Dehydrogenase/Urease/Amylase activity: reduction of triphenyl tetrazolium chloride (TTC) by dehydrogenases/ detection of ammonia by phenol red or Nessler's reagent/ detection of amylase using iodine solution

UNIT – 3 (3 Weeks)

Biodegradation of organic matter and Trichoderma as biocontrol agent: Demonstration of steps of organic matter decomposition: composting of plant and food wastes containing organic compounds-lignin, cellulose, hemicellulose, polysaccharides, proteins, lipids, etc. into simple inorganic compounds/elements to be used as soil conditioner. Demonstration of antagonistic activity of *Trichoderma sp*. against different fungi (any 2) using dual culture plate technique.

Essential/recommended readings

1. Benson's Microbiological Applications, Laboratory Manual in General Microbiology by A. Brown and H. Smith.15th edition. McGraw-Hill Education, USA. 2022.
2. Biopesticides and Bioagents: Novel tools for pest management by M. A. Anwer. 1st edition.Apple Academic Press, USA. 2021.
3. Brock Biology of Microorganisms by M.T. Madigan,J. Aiyer,D. Buckley,W.Sattley and D. Stahl.16th edition. Pearson, USA. 2021.
4. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition. Pearson Education, USA. 2020.
5. Soil Microorganisms and plant growth by N.S., Subba Rao. 4th edition. Oxford & IBH Publishing Co. Pvt. Ltd. India. 2020.
6. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGraw Hill Higher Education, USA. 2019.
7. Biofertilizers in Agriculture and Forestry by N.S., Subba Rao. 4th edition. Biogreen Publisher, India. 2009.
8. Agricultural Microbiology by G. Rangaswami. and D. J., Bagyarai. 2nd edition, Prentice-Hall of India Private Limited, New Delhi. 2005.
9. Principles and Applications of Soil Microbiology by D.M., Sylvia. J.J., Fuhrmann. P.J. Hartel and D.A., Zuberer. 2nd edition Pearson, Prentice Hall, USA. 2005.
10. Agricultural Biotechnology by S.S., Purohit. 2nd edition. Agrobios Publisher, Jodhpur, India. 2003.

Suggestive readings (if any)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-10: MICROBIAL PRODUCTS IN THERAPEUTICS)

Credit distribution, Eligibility and Pre-requisites of the Course

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lecture	Tutorial	Practical/ Practice			
MICROB-GE10: MICROBIAL PRODUCTS IN THERAPEUTICS	4	2	0	2	None	NIL	Microbiology

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to give students an in-depth knowledge of the commercially available microbial products used in the treatment of human diseases and their management.
- Students will be acquainted with the large-scale culturing of microorganisms to produce various metabolites used for therapeutic purposes.
- Students will get an hands-on experience in the production of enzymes by microorganisms and production of fermented foods.
- They will learn to use bioassay for detecting an antibiotic in a sample and they will get familiar with the technique to determine antibiotic sensitivity of any bacterial culture..

Learning outcomes

The Learning Outcomes of this course are as follows:

- The student be able to describe the techniques involved in isolation, screening and mass culturing of microorganisms to produce microbial metabolites at the industrial scale.
- The student would be able to describe the microbial therapeutics used in the management of infectious and non-infectious diseases in humans.
- The student be able to demonstrate and/or describe the extracellular enzyme production by microorganisms and its detection in the broth, and the production of fermented food products involving microorganisms.
- The student would be able to demonstrate the concept of bioassay for the detection of an antibiotic in the sample, and differentiate between antibiotic sensitive and antibiotic resistant bacteria.

- The student be able to collect and analyse data of commercially available therapeutic products and on locally available fermented foods.

SYLLABUS OF MICROB-GE10

UNIT – I (5 Weeks)

Isolation, screening and mass culturing of microorganisms to produce useful metabolites: Sources of industrially important microbes, their isolation and screening (primary and secondary). Fermentation techniques for large scale culturing: batch, fed-batch, continuously stirred tank reactor, solid-state fermentation. Different methods for recovery of microbial products

UNIT – II (5 Weeks)

Microbial therapeutics in the treatment of infectious diseases: Antibiotics: mode of action, uses, and producer organisms of penicillin, streptomycin, tetracycline, cephalosporin, neomycin, erythromycin, augmentin, vancomycin and griseofulvin. Antimicrobial Resistance (AMR) phenomenon. Enzybiotics: Mode of action, uses and producer microorganisms of bacteriocins and lysozyme. Probiotics: Features of effective probiotics, benefits, commonly used probiotic microorganisms (Lactobacillus sp., Bifidobacterium sp., Saccharomyces boulardii). Bacto therapy by microbiota transplant.

UNIT – III (5 Weeks)

Microbial therapeutics in the treatment of non -infectious diseases: Mode of action, uses and producer microorganisms of the following biopharmaceuticals: anti-inflammatory agents (serratopeptidase and collagenase), thrombolytic agents (streptokinase, nattokinase, tissue plasminogen activator), digestive aids (fungal amylase and lipase), anticancer agents (asparaginase, methioninase), vitamins (cyanocobalamin,riboflavin), hormones (insulin and somatostatin). Production of steroid- based pharmaceuticals by microbial transformation: dehydrogenation (cortisol to prednisolone), hydroxylation (progesterone to11α hydroxyprogesterone).

Practical component –

UNIT – 1 (6 Weeks)

Production of enzymes and fermented foods: Production of amylase from fungi and its detection in the culture broth: medium preparation, sterilization by autoclaving, inoculation, fermentation under specified condition of temperature and product harvesting from the broth by filtration. Production of any fermented product having probiotic bacteria or yeast (sauerkraut /curd / kanji). Estimation of lactic acid produced during curd formation by titration

UNIT – 2 (6 Weeks)

Detection of antibiotics and determination of antibiotic susceptibility: Bioassay to detect the presence of an antibiotic in the broth/ provided samples: spreading an antibiotic sensitive bacterial culture on nutrient agar plates, making wells in the plates and dispensing antibiotic dilutions in the wells. Measuring zone of inhibition following incubation. Determination of the sensitivity of a bacterial culture to antibiotics using Kirby -Bauer disc diffusion method: spreading a bacterial cul-

using sterile swab on Mueller -Hinton agar and determination of susceptibility of the bacterial culture to different antibiotic discs

UNIT – 3 (3 Weeks)

Data collection and report preparation: Student research study project: Market survey of commercially available pharmaceutical products of microbial origin. Report preparation of locally fermented food and dairy products. Presentation of main findings.

Essential/recommended readings

1. Industrial Microbiology by A.H. Patel. 2nd edition. Laxmi publication Pvt Ltd/Trinity Press. 2022.
2. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition. Pearson Education, USA. 2020.
3. Industrial Microbiology by L.E. Casida. 2nd edition. New Age International publisher. 2019.
4. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGrawHill Higher Education, USA. 2019.
5. Crueger's Biotechnology: A Textbook of Industrial Microbiology by W. Crueger,
6. A. Crueger and K.R.Aneja. 3rd edition. Medtech Publisher, India. 2017.
7. Principles of Fermentation Technology by P.F. Stanbury, A.Whitaker and S.J. Hall. 3rd edition. Elsevier Science Ltd, Netherlands. 2016.
8. Benson's Microbiological applications: Laboratory manual in general microbiology by A.E. Brown and H. Smith H. 15th edition. McGraw-Hill Education, USA. 2022.
9. Pharmaceutical Biotechnology: Fundamentals and Applications edited by J. Crommelin, R. Sindelar and B Meibohm B. 4th edition. Springer, UK. 2013.
10. Manual of Industrial Microbiology and Biotechnology edited by R.H. Baltz, A.L. Demain, and J.E. Davies. 3rd edition. American Society for Microbiology. 2010.
11. Pharmaceutical Biotechnology: Concepts and Applications by G. Walsh. John Wiley and Sons. 2007.

Suggestive readings (if any)

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 7: BASIC CONCEPTS OF CELL BIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSC301: BASIC CONCEPTS OF CELL BIOLOGY	4	3	0	1	Class XII pass with Biology/ Biotechnology/ Biochemistry	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to introduce the students to the essentials of eukaryotic cell biology. The students will gain knowledge about the physical and chemical architecture of cells as well as structural and functional details of different cell organelles.
- To familiarize the students with cell cycle events, and mechanisms of cell communication and cell death. They will be educated about the hallmarks, etiology and diagnosis of cancers. They will be introduced to the cutting-edge science of stem cell technology, their production and various applications

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to describe the structure of the cell wall and cell membrane, membrane transport mechanisms, cell-matrix and cell-cell interactions, and the importance of the cytoskeleton.
- Student will be able to describe the organization and functioning of various cell organelles and gain insights into the internal organization of the nucleus.
- Student will be able to discuss the mechanisms of protein sorting, intracellular trafficking, and protein export.
- Student will be able to analyse the structure of the plant and animal cell by microscopic observation and the ultrastructure of cell organelles by electron microscopy.

- Student will be able to demonstrate the fractionation of cell components by ultracentrifugation and describe cell sorting by flow cytometry.

SYLLABUS OF DSC-7

UNIT – I (12 hours)

Cell envelope and cell interactions: Structure and composition of bacterial, fungal and plant cell walls. Composition of plasma membrane: phospholipid bilayer, membrane proteins, glycocalyx. Membrane transport mechanisms: passive diffusion, facilitated diffusion (carrier proteins and channel proteins), active transport (Na+-K+ ATPase, ABC transporters). Components of extracellular matrix: polysaccharides, structural proteins, adhesion proteins. Cell-matrix interactions: cell surface receptors, focal adhesions, hemi-desmosomes. Cell-cell interactions: adhesion junctions, tight junctions, gap junctions, plasmodesmata

UNIT – II (6 hours)

Cytoskeleton: structural organization of actin filaments, microtubule structure and dynamics, structure of centriole, cilia, flagella. Microtubule motor proteins: kinesins and dyneins.

UNIT – III (12 hours)

Structures and functions of nucleus and other cell organelles: Structure and function of nucleus and its components (nuclear envelope, nuclear lamina, nuclear pore complex). Internal organization of nucleus: heterochromatin, euchromatin, nucleolus. Structure and function of cell organelles: mitochondrion, chloroplast, ribosome, peroxisome, lysosome

UNIT – IV (15 hours)

Protein sorting and membrane trafficking: Structure of endoplasmic reticulum (smooth and rough, ER transmembrane proteins). Targeting and translocation of proteins across the endoplasmic reticulum, protein processing, folding and assembly. Brief overview of the role of endoplasmic reticulum in synthesis of lipids and assembly of phospholipid bilayers. Structure and organization of golgi apparatus. Protein glycosylation, protein sorting, and exocytosis. Signal sequences in transmembrane transport: nuclear localization signal, endoplasmic reticulum signal sequence

Practical component **30 Hours**

UNIT 1: (20 hours)

Cell and cell organelles: Use of light microscopy and electron microscopy in studying cells. Study of the structure and function of a plant cell and an animal cell through microscopy. Analysis of the ultrastructure of cell organelles through electron micrographs: nucleus, plasma membrane, mitochondrion, chloroplast, ribosome, endoplasmic reticulum, golgi bodies, lysosome, centriole

Unit 2: (10 hours)

Cell fractionation and sorting: Principle and working of cell fractionation by density gradient centrifugation using virtual lab. Principle and working of cell sorting by flow cytometry using virtual lab. Analysis of cell cycle stages using flow cytometry.

Essential/recommended readings

Theory:

1. Molecular Cell Biology by H. Lodish, A. Berk, C. Kaiser, M. Krieger, A. Bretscher, H.Ploegh, A. Amon and K.C. Martin. 9th edition. W.H. Freeman, UK. 2021.
2. Essential Cell Biology by B. Alberts, K. Hopkin, A.D. Johnson, D. Morgan, and M. Raff. 5th edition. W.W. Norton & Co, USA. 2019.
3. Karp's Cell and Molecular Biology by G. Karp, J. Iwasa and W. Marshall. 9th edition. Wiley, USA. 2019.
4. The Cell: A Molecular Approach by G.M. Cooper. 8th edition. Sinauer Associates, UK. 2018.
5. Cell Biology by T.D. Pollard, W.C. Earnshaw, J. Lippincott-Schwartz and G.T. Johnson. 3rd edition. Elsevier, USA. 2016.
6. Becker's World of the Cell by J. Hardin and G. Bertoni. 9th Edition. Pearson, USA. 2015.
7. Cell and Molecular Biology by E.D.P. De Robertis. 8th edition. Lippincott, Williams and Wilkins, USA. 2006.

Practicals:

1. A Cell Biology Manual by J. Francis. Kendall/Hunt Publishing Co, USA. 2022.
2. Practical Laboratory Manual- Cell Biology by A. Gupta, B.K. Sati. Lambert Academic Publishing, USA. 2019.
3. Cell Biology Practical Manual by R. Gupta, S. Makhija and R. Toteja. Prestige Publishers, India. 2018.
4. Laboratory Manual of Cell Biology by R. Majumdar, R. Sisodia. Prestige Publishers, India. 2018.
5. Essential Cell Biology Vol 1: Cell Structure- A Practical Approach by J. Davey and M.Lord. Oxford University Press, UK. 2003.
6. Essential Cell Biology Vol 2: Cell Function- A Practical Approach by J. Davey and M. Lord. Oxford University Press, UK. 2003.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE –8:
MICROBIAL PHYSIOLOGY AND METABOLISM- I

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSC302: **MICROBIAL PHYSIOLOGY AND METABOLISM- I**	**4**	**3**	**0**	**1**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to enable students to understand the underlying mechanisms governing various physiological and metabolic features of prokaryotes. These include transport mechanisms for the uptake of nutrients, bacterial growth, and the diversity of prokaryotes due to (i) adaptations to the different habitats in which they grow and (ii) metabolic pathways for energy production and carbon and nitrogen assimilation.
- The course will build the strong foundation needed by the students for further studies in the advanced fields of microbiology including metabolic engineering.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to discuss the diverse nutritional categories of bacteria/archaea and mechanisms of transport of nutrients across membranes of microbes.
- Student will be able to describe the physiology of bacterial growth, calculation of generation time and specific growth rate, and the effects of physicochemical factors on microbial growth.
- Student will be able to describe the metabolic pathways used by bacteria for energy generation and conservation during growth on glucose and other carbon sources under aerobic and anaerobic conditions.
- Student will be able to discuss energy production processes in microbes.

- Student will be able to analyse growth kinetics of bacteria, and evaluate the impact of external factors on bacterial growth kinetics.

SYLLABUS OF DSC-8

UNIT – I (10 hours)

Nutritional diversity amongst bacteria and mechanisms of nutrients transport: Classification of bacteria based on carbon, electron and energy sources. Nutrient transport across membrane: passive transport (diffusion- simple and facilitated), active transport (primary and secondary with suitable examples, concept of uniport, symport, antiport) and group translocation. Electrogenic and electroneutral transport. Transport of iron in bacteria through concerted action of primary and secondary active transport.

UNIT – II (12 hours)

Microbial growth patterns, kinetics and physiological adaptations: Batch, continuous, diauxic and synchronous growth. Bacterial growth kinetics: growth curve, generation time and specific growth rate. Physiological adaptations by microbes for growth under different environmental conditions: effect of temperature, pH, oxygen concentration, solute and water activity.

UNIT – III (12 hours)

Chemoheterotrophic metabolism under aerobic conditions: Concept of metabolism and energy production. Glucose degradation/catabolism by microbes via: glycolysis, Entner-Doudoroff (ED) pathway, Pentose phosphate pathway (PPP). The pyruvate dehydrogenase reaction, Krebs Cycle, anaplerotic reactions, Glyoxylate cycle. Utilization of fructose, lactose and pentose

UNIT – IV (11 hours)

Electron transport and energy production: Redox potentials of the electron carriers, organization of electron carriers in mitochondria, coupling sites, mechanisms of proton translocation, chemiosmotic hypothesis, oxidative phosphorylation and ATP generation, uncouplers and inhibitors of respiratory chain, comparison of mitochondrial and bacterial electron transport, branched respiratory chain in E. coli under high and low levels of O_2.

Practical component **30 Hours**

UNIT 1: (20 hours)

Microbial growth: Study of various methods of measurement of microbial growth. Collection of data and plotting of bacterial growth curve of E. coli using turbidometric method (using optical density as the indirect method of measurement of bacterial growth). Understanding bacterial growth kinetics by calculation of generation time and specific growth rate of bacteria from the graph. Study of radial growth of *Aspergillus niger* using point inoculation method

Unit 2: (10 hours)

Effect of environmental factors on microbial growth: Study of the effect of physicochemical factors like temperature and pH variations on the growth of *E.coli*. Understanding the physiological importance of catalase and oxidase in protecting bacteria from the harmful effects of oxidizing environment: detection and assay of their activity in bacteria.

Essential/recommended readings

Theory:

1. Lehninger Principles of Biochemistry by D.L. Nelson and M.M. Cox. 8th edition. W.H. Freeman Fundamentals of Bacterial Physiology and Metabolism by Rani Gupta and Namita Gupta. Springer Nature Singapore Pvt. Ltd., Singapore. 2021.
2. Lehninger Principles of Biochemistry by D.L. Nelson and M.M. Cox. 8th edition. W.H. Freeman and Company, UK. 2021.
3. Brock Biology of Microorganisms by M.T. Madigan,J. Aiyer,D. Buckley,W.Sattley and D. Stahl.16th edition. Pearson, USA. 2021.
4. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGrawHill Higher Education, USA. 2019.
5. Microbial Biochemistry by G.N. Cohen. 2nd edition. Springer, Germany. 2014.
6. The Physiology and Biochemistry of Prokaryotes by D. White, J. Drummond and C. Fuqua. 4th edition. Oxford University Press, UK. 2011.
7. Microbial Physiology by S.R. Reddy and S.M. Reddy. Scientific Publishers India. 2007.
8. Microbial Physiology by A.G. Moat, J.W. Foster and M.P. Spector. 4th edition. John Wiley& Sons, USA. 2002.

Practicals:

1. Essentials of Practical Microbiology by A. Sastry and S. Bhat. 2nd edition. Jaypee Brothers Medical Publishers, India. 2021.
2. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition. Pearson Education, USA. 2020.
3. Laboratory Experiments in Microbiology by T. Johnson and C. Case. 12th Edition. Pearson Education, USA. 2019.
4. Microbiology Practical Manual edited by A. Jain, J. Agarwal, V. Venkatesh. Elsevier, India. 2018.
5. Applied Microbial Physiology: A Practical Approach by P. M. Rhodes and P. F. Stanbury. IRC Press. 1997.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 9: ENVIRONMENTAL MICROBIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSC303: ENVIRONMENTAL MICROBIOLOGY	**4**	**3**	**0**	**1**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this paper is to provide students with in-depth knowledge of diverse microbial populations/ communities present in different habitats in the ecosystem.
- Students will become aware of the inter-microbial, microbe-plant and microbe-animal interactions and their benefits. The students will also learn about the management of solid and liquid waste and different strategies for microbial remediation of environment pollutants.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to discuss natural habitats of diverse microbial populations and give an overview of the concept of metagenomics.
- Student will be able to analyse various positive and negative interactions amongst microbes and also between microbes and plants / animals.
- Student will be able to explain the importance of microorganisms in mineral cycling within an ecosystem, and their effects on the environment.
- Student will be able to discuss various methods involved in sewage treatment, how we can make water safe for drinking, and various methods for testing water potability.
- Student will be able to evaluate different waste management strategies using microorganisms.
- Student will be able to describe various methods of microbial remediation for treating pollutants present in our environment. Student will be able to determine the importance of quality control in the food industry and describe various indices being used to measure quality and safety in the food industry.

SYLLABUS OF DSC-9

UNIT – I (11 hours)

Natural habitats and their microbial communities: Concepts of habitat, niche. Autochthonous, allochthonous, zymogenous microorganisms. Colonization and succession. Lithosphere: Soil profile, soil characteristics: physical and chemical, soil microbial community. Hydrosphere: Freshwater habitat: stratification and microbial composition of lake. Marine habitat: stratification and microbial composition of ocean. Atmosphere: atmosphere as microbial habitat, dispersal of microorganisms/spores, bioaerosols, methods of air sampling (filtration and deposition). Extreme habitats with reference to temperature, hydrostatic pressure, salinity and low nutrient levels. Concept of metagenomics, use of metagenomics to profile microbial communities in natural habitats.

UNIT – II (9 hours)

Interactions of microbial populations: Microbe-microbe interactions. Positive interactions: mutualism, protocooperation, commensalism. Negative interactions: antagonism, competition, predation, parasitism. Microbe-plant interactions. Symbiotic association: microbes associated with roots and aerial plant surfaces, leguminous roots-rhizobium symbiosis, Anabaena-Azolla symbiosis, mycorrhizal and actinorhizal associations. Microbe- animal interactions. Microflora in ruminant gut, nematophagous fungi and symbiotic luminescent bacteria.

UNIT – III (9 hours)

Mineral cycling by microbes and their effects on the environment : Importance of biogeochemical cycles. Carbon cycle: microbial degradation of cellulose, lignin and chitin, Nitrogen cycle: nitrogen fixation, ammonification, nitrification, denitrification and nitrate reduction. Phosphorus cycle: solubilisation and immobilization. Sulphur cycle: oxidative and reductive sulphur transformation, metal corrosion, acid mining drainage, nitrate pollution

UNIT – IV (9 hours)

Wastewater treatment and water potability: Sources and composition of liquid waste. Sewage strength: BOD and COD. Primary, secondary (aerobic: trickling filter, activated sludge process; anaerobic: septic tank, anaerobic sludge digestor) and tertiary sewage treatment. Treatment and safety of drinking (potable) water, Methods to detect potability of water samples: standard qualitative procedure - presumptive test/MPN test, confirmed and completed tests for fecal coliforms; membrane filter technique and Presence/Absence tests for coliforms, Indicator microorganisms.

UNIT – V (7 hours)

Disposal of solid waste by microbes and microbial remediation of environment: Sources and types of solid waste. Methods of solid waste disposal: sanitary landfills, composting (static piles, aerated piles and continuous feed reactors). Concepts of xenobiotics, recalcitrant compounds and bioremediation. Biodegradation of pesticides (DDT and Propanil), oil spills, e-waste and plastics.

Practical component **30 Hours**

UNIT 1: (15 hours)

Soil microflora:

Study of the presence of microbial activity in soil by qualitative detection of enzyme activity: dehydrogenase, amylase, urease. Microbial interactions: Isolation and quantitation of bacteria from rhizosphere and root-free soil to determine the rhizosphere effect. Isolation of symbiotic and non-symbiotic nitrogen fixers: *Rhizobium* and *Azotobacter* or *Azospirillum*.

Unit 2: (15 hours)

Mineral cycling and waste management by microbial remediation: Demonstration of phosphate solubilization by plate isolation method. Student group project: Preparation of Winogradsky column mini aquatic ecosystem. Assessment of the microbiological quality of water by standard qualitative procedures. Determination of BOD of wastewater sample by Dissolved Oxygen Electrode method/ Winkler's method. **Student group project**: Sewage surveillance in the fight against COVID19.

Essential/recommended readings

Theory:

1. Brock Biology of Microorganisms by M.T. Madigan,J. Aiyer,D. Buckley,W.Sattley and D. Stahl.16th edition. Pearson, USA. 2021.
2. Microbial bioremediation by P. Rajendran and P. Gunasekaran. 1st edition, MJP Publishers, India. 2019.
3. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGrawHill Higher Education, USA. 2019.
4. Environmental microbiology by K.V. Ramesh. MJP Publisher. 2019.
5. Soil Microbiology by N.S. Subba Rao. 5th edition. Medtech, India. 2017.
6. Wastewater Microbiology by D.H. Bergey. Medtech, India. 2014.
7. Environmental Biotechnology by M. Jain. 1st Edition. Alpha Science International Ltd. 2014.
8. Environmental Microbiology edited by I.L. Pepper, C.P. Gerba, T.J. Gentry. 3rd edition.Academic Press, USA. 2014.
9. Microbial ecology by L.L. Barton and D.E. Northrup. 1st Edition. John Wiley & Sons. 2011.
10. Environmental Microbiology of Aquatic and Waste Systems by N. Okafor. Springer, USA.2011.
11. Environmental Biotechnology: Basic Concepts and Applications by I.S. Thakur. 2nd Edition. I K International Publishing House Pvt. Ltd. 2011.
12. Advances in Applied Bioremediation edited by A. Singh, R.C. Kuhad and O. P. Ward.Springer-Verlag, Germany. 2009.
13. Microbial Ecology: Fundamentals and Applications by R.M. Atlas, R. Bartha. 4th edition.Benjamin Cummings, USA. 2000.
14. Principles of Microbiology by R. M. Atlas. 2nd edition. W.M.T. Brown Publishers, USA.1997.

Practicals:

1. Benson's Microbiological Applications, Laboratory Manual in General Microbiology by A. Brown and H. Smith. 15th edition. McGraw-Hill Education, USA. 2022.
2. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition. Pearson Education, USA. 2020.
3. Experiments in Microbiology, Plant Pathology and Biotechnology by K. R. Aneja. 5th edition. New Age International Publishers, India. 2017.
4. Manual of Environmental Microbiology by C. J., Hurst, R. L., Crawford, J. L., Garland and D. A. Lipson. American Society for Microbiology Press. USA. 2007.
5. Microbial Ecology: Fundamentals and Applications by R.M. Atlas and R. Bartha. 4th edition. Benjamin Cummings, USA. 2000.
6. Methods in Applied Soil Microbiology and Biochemistry by K. Alef and P. Nannipieri. Ist edition. Academic Press, USA. 1995.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 1:
EUKARYOTIC MICROBES: BIOLOGY AND BIOTECHNOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE1: **EUKARYOTIC MICROBES: BIOLOGY AND BIOTECHNOLOGY**	**4**	**2**	**0**	**2**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of the course is to make students familiar with eukaryotic microorganisms namely algae, protozoa and fungi. They will become aware of their characteristics and applications in various fields such as industry, food, environment and medical science.
- They will understand how eukaryotic microbes can be used to develop eco-friendly and sustainable solutions to problems we are encountering in various fields.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to explain the characteristics of major algal types, the applications of micro and macro algae in different fields, and algae mass cultivation methods.
- Student will be able to describe different types of protozoa and their salient features, the significance of protozoa in medical, environmental and other fields.
- Student will be able to explain the characteristics of different types of fungi, their benefits and harmful effects, the biology and commercial importance of mushrooms.
- Student will be able to demonstrate the isolation and identification of green algae from pond water, the extraction and analysis of chlorophyll pigment. They will be able to discuss the thallus organization of different types of algae and the taxonomic position of Euglena.
- Student will be able to identify different types of protozoa and explain their major characteristics, the life cycles of some protozoa which cause diseases transmitted through insects or by contaminated food and water.

- Student will be able to describe different types of fungi and will be able to identify them based on their macroscopic and microscopic characteristics. They will be able to demonstrate fungal techniques, the difference between edible and poisonous mushrooms, steps of mushroom cultivation through visit to mushroom cultivation centre.

Theory component

Unit 1: (10 hours)

Algae structure, ecology and significance: General characteristics and brief account of habitat and thallus organization of major algal types: Chlorophyta, Bacillariophyta, Dinoflagellates, Xanthophyta, Phaeophyta and Rhodophyta. Applications of algae in wastewater treatment, biofuel and bioenergy products, pharmaceutical industries and food and feed sectors with reference to *Chlorella, Euglena, Dunaliella, Porphyra, Gracilaria,* diatoms*, Sargassum* and *Laminaria.* Mass cultivation of algae in open and closed photobioreactors.

Unit 2: (10 hours)

Protozoa structure, ecology and significance: An overview of habitat, cell structure, locomotion, and nutrition of different protozoa: *Entamoeba, Plasmodium, Giardia, Tetrahymena, Trypanosoma and Leishmania*. Disease causing protozoa: list of diseases, causative agent, mode of transmission, preventive measures currently in use (if any). Significance of protozoa in food web and water purification. Marine protozoa as source of filtering agents, chalk, abrasive and building material. Role of protozoa in symbiosis therapy and drug discovery. Role of *Tetrahymena* as model organism.

Unit 3: (10 hours)

Fungal structure, ecology and significance: An overview of habitat, thallus structure, nutrition and positive and negative importance (ecological, industrial, and medical) of different fungi: *Neocallimastix, Saccharomyces, Penicillium, Neurospora, Agaricus* and *Armillaria.* Detailed account of biology and commercial importance of Mushrooms: History, classification and distribution, life cycle, cultivation, nutrient and medicinal values; Edible and poisonous mushrooms.

Practical component **60 Hours**

Unit 1: (24 hours)

Isolation, identification and pigment analysis of algae: Study of the following algae by temporary mounts/permanent slides/photographs (at least one alga to be studied by making temporary mounts): *Chlorella, Porphyra, Gracilaria,* diatoms*, Sargassum, Dunaliella, Caulerpa, Ulva.* Comparison of the vegetative thallus organization. Isolation

of green algae from pond water and their identification by making temporary mounts. Recording of macroscopic and microscopic characterteristics of isolated algae. Extraction of pigment (chlorophyll) from algae and its analysis using chromatography or spectrophotometry. Study of the structure of *Euglena* cell highlighting its algal and protozoa characteristics discussion of its 'taxonomic enigma' status.

Unit 2: (16 hours)

Identification of protozoa and their importance: Study of different protozoa (*Entamoeba, Plasmodium, Giardia, Tetrahymena, Trypanosoma and Leishmania***)** with the help of permanent slides / photographs. Comparison of their structure and important characteristics. Study of the different stages of disease cycles of arthropod-borne protozoal diseases (*Plasmodium, Trypanosoma* and *Leishmania*) with the help of pictorial aids. **Student research study project**: Transmission, symptoms, prevention and cure of these diseases. Study of food and water-borne diseases caused by protozoa (*Entamoeba* and *Giardia*) in reference to life cycle, transmission, symptoms, prevention and cure. Comparison of the disease cycles of *Entamoeba* and *Giardia*.

Unit 3: (20 hours)

Identification of fungi and their importance: Study of fungi by temporary mounts/ permanent slides/photographs (at least one fungus to be studied by making temporary mounts): *Neocallimastix, Saccharomyces, Penicillium, Neurospora, Agaricus* and *Armillaria.* Observation of macroscopic and microscopic identifying characteristics. Preparation of spore suspension of fungus (*Aspergillus niger*) and counting of spores / ml using hemocytometer. Study of edible and poisonous mushrooms with the help of samples/photographs. Visit to mushroom cultivation center to learn various steps involved in mushroom cultivation.

Suggested Reading (Theory & Practical):

1. Brock Biology of Microorganisms by M.T. Madigan,J. Aiyer,D. Buckley,W.Sattley and D. Stahl.16th edition. Pearson, USA. 2021.
2. A Textbook on Mushroom Cultivation: Theory and Practice by A. Aggarwal, Y. P. Sharma, and E.Jangra.1st edition. Newrays Publishing House, India. 2021.
3. Prescott's Microbiology by J.M.Willey, K.Sandman and D. Wood. 11th edition. McGraw Hill Higher Education, USA. 2019.
4. Paniker's Textbook of Medical Parasitology by C.K. J. Paniker and S. Ghosh.8th edition. Jaypee Brothers Medical Publishers, India. 2018.
5. Laboratory Manual for Algae and Fungi by B.K.Chetri.1st edition.Lulu.com publisher.2018.
6. Textbook of Algae by O.P.Sharma. Tata McGraw Hill Publishing Co. Ltd, India. 2017.

7. Algae Biotechnology: Products and Processes by F.Bux, and Y. Chisti (Eds.) 1st edition. Springer International Publishing, USA. 2016.

8. Algae: Anatomy, Biochemistry, and Biotechnology by L. Barsanti and P.Gualtieri. 2nd edition.CRC Press, Taylor and Francis group,USA. 2014.

9. Introductory Mycology by C.J. Alexopoulos, C.W. Mims and M. Blackwell. 4th edition. John Wiley and Sons, New York. 2012 (reprint).

10. Manual of Soil Fungi by J.C. Gilman. 1st edition. Biotech Books, India. 2012 (Reprint).

11. Introduction to Fungi by J. Webster and R.W.S. Weber. 3rd edition. Cambridge University Press. USA. 2007.

12. The Fungi by G.Sumbali. 2nd edition. Narosa Publishing India House, India. 2005.

13. Protozoa by R.L. Kotpal. 12th edition. Rastogi Publication, India. 2006.

14. Manual of Phycology by G.M.Smith.1st edition. Scientific Publishers Journals, India.1994

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 2:
Applications of Statistics in Biology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE2: Applications of Statistics in Biology	4	2	0	2	Class XII pass with Biology/ Biotechnology/ Biochemistry	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to enable the students to understand the basic concepts of statistics and how statistics helps in analysing biological data by using simple examples. Students will learn to handle biological data using statistical tools and to draw appropriate conclusions from the analysis.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to explain the collection and analysis of data through descriptive statistics, measures of skewness and kurtosis, Discrete and Continuous Random variable; with emphasis on examples from biological sciences.
- Student will be able to describe correlation and regression, various Discrete and Continuous Distributions namely Binomial, Poisson, Exponential and Normal distribution.
- Student will be able to explain different statistical methods, principles of statistical analysis of biological data, sampling parameters.
- Student will be able to describe large sample test based on normal distribution, and small sample test based on t-test and F test

Contents:

Theory: **30 hours**

Unit 1: (10 hours)

Data collection and handling: Collection, Classification, Tabulation and Graphical representation of Data. Measure of central tendency and dispersion. Correlation and Regression analysis: Relation between two variables, curve fitting, two regression lines, Karl Pearson's coefficient of correlation.

Unit 2: (10 hours)

Probability, variables and types of distribution: Probability theory and concept of Random Variable (discrete and continuous), Standard distributions: Exponential distribution, Binomial distribution, Poisson distribution, Normal distributions.

Unit 3: (10 hours)

p-value and sample tests: Sampling Distributions, Testing of Hypothesis, Level of Significance and Degree of Freedom; Interpretation and significance of p-value. Large Sample Test based on Normal Distribution, small sample test based on t-test and F test.

Practicals: **60 hours**

Unit 1: (20 hours)

Handling of data, dispersion, Karl Pearson coefficient, and regression analysis using Excel: Handling of data using measures of central tendency; handling of data using measures of dispersion; finding Karl Pearson correlation coefficient and interpretation of result; Spearman rank correlation with and without ties; how to obtain regression lines.

Unit 2: (20 hours)

Distributions (Practical Using Excel): Fitting of binomial distributions for n and p = q = ½ given; fitting of Poisson distributions for given value of lambda; application problems based on binomial distribution; application problems based on Poisson distribution; problems based on area property of normal distribution; finding the ordinate for a given area for normal distribution; application based problems using normal distribution

Unit 3: (20 hours)

Sample tests and their applications (Practical Using Excel): Problems based on Large Sample Tests and interpretation of result; estimators of population mean when Population is large; Tests of hypotheses for the parameters of a normal distribution-Single Mean; Tests of hypotheses for the parameters of a normal distribution -Difference of Means; application of t-test- single mean, difference of means and Paired t-test; application of F- test and interpretation of result on given data set.

Suggested reading (Theory & Practical):

1. Introduction to the Theory of Statistics by A.M. Mood, F.A. Graybill and D. C. Boes. 3rd edition (Reprint). Tata McGraw-Hill, India. 2017.
2. An Introduction to Medical Statistics by M. Bland. 4th edition. Oxford University Press USA, 2015.
3. An Introduction to Biostatistics by N. Gurumani. 2nd edition. MJP publishers, India. 2014.
4. An introduction to Biostatistics and Research Methods by PSS Sunder Rao and J. Richard. 5th edition. PHI learning, India. 2012.
5. Fundamentals of Statistics (Vol. I & II) by A. M. Goon, M. K. Gupta and B. Dasgupta. 8th edition. The World Press, India. 2008.
6. Mathematical Statistics with Applications by I. Miller and M. Miller. 7th edition, Pearson Education, Asia. 2006.
7. Biostatistics: A Foundation for Analysis in the Health Sciences by Daniel, Wayne W. John Wiley, UK. 2005.
8. Fundamentals of Biostatistics by Irfan A Khan. Ukaaz Publications, India. 1994.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 3:
MICROBIAL QUALITY CONTROL IN FOOD AND PHARMACEUTICAL INDUSTRIES

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
MICROB-DSE 3: MICROBIAL QUALITY CONTROL IN FOOD AND PHARMACEUTICAL INDUSTRIES	**4**	**2**	**0**	**2**	**Class XII pass with Biology/ Biotechnology / Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is for students to develop an understanding of the concept and implementation of microbial quality control in the food and pharmaceutical industries.
- Students will gain insights into how the final products obtained for human and animal consumption are consistent, certified as safe for human consumption, and compliant with microbial standards.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to describe the parameters and techniques of Good Laboratory and Microbiological practices, sources of contamination, microbial monitoring of the environment and the concept of clean areas in the industry.
- Student will be able to explain the techniques of collecting and processing food, water and pharmaceutical samples for bioburden testing, various microscopic, culturing, biochemical, molecular and immunological testing techniques used for assessing the presence of microbes/pathogens as well as the toxic microbial products.
- Student will be able to describe Total Quality Management (TQM) system and Standard Operating Procedures (SOP) for fulfilling the requirements of Quality

Control (QC) are created, various microbiological standards and certifications by accrediting bodies for food and pharmaceutical industries.

- Student will be able to demonstrate the techniques for checking milk quality by performing rapid and standard laboratory tests, method of testing of microbiological quality of water samples (Most Probable Number).
- Student will be able to describe how the food sample is processed for the detection of microorganisms, various differential and selective media to detect and identify different microorganisms present in a food sample.
- Student will be able to demonstrate sterility testing of various food and pharmaceutical products under different conditions.
- Student will be able to develop HACCP flow charts for different products, the application of various standards in quality regulation in food and pharma products with the help of case studies.

Contents:

Theory: **30 hours**

Unit 1. (8 hours)

Microbiological safe practices for food and pharmaceutical industry: Laboratory practices for safety and quality (GLP and GMLP). Concept of Biosafety cabinets. Biosafety
levels (BSL-I to BSL-IV): designs, specifications and uses. Concept of Clean Area and its classification. Microbial monitoring of controlled environments (bioburden). Sources of contamination in food and pharmaceutical industries. Steps to avoid contamination. Food Safety, Sanitation Standard Operating Procedure (SSOP) and Personal Hygiene**.**

Unit 2: (14 hours)

Monitoring and analysis of microbiological quality of food and pharmaceutical samples: Types of products in food and pharmaceutical industries. Bioburden testing for food, beverages and medical devices. Collection and processing of samples for microbiological monitoring. Detection of microorganisms by microscopic method (fluorescence-based Direct Microscopic Count). Detection of microorganisms by cultural methods: enrichment technique, standard plate count, the concept of differential and selective media for detection of pathogens (XLD agar, Salmonella-Shigella agar, Mannitol salt agar, EMB agar, McConkey agar). Microbiological examination of non-sterile pharmaceutical products, concept of microbial limits, sterility testing (its objectives and significance). Molecular, biochemical and immunological methods for detection of microorganisms and their products (Nucleic acid probes, PCR, biosensors, Limulus lysate test, pyrogen testing). Significance of rapid detection methods (Clot on

Boiling Test, dye reduction test by Resazurin) in food industry.

Unit 3: (8 hours)

Microbial quality standards and management: Introduction and importance of quality standards. Concepts and approaches of Total Quality Management (TQM), Quality Management System, ISO 9001:2000, Quality Assurance and Quality Control. Development of Standard Operating Procedures. Hazard analysis of critical control point (HACCP): principles, applications and limitations. Concept of Codex Alimentarius and Codex Standards. Role of accredited certification bodies (BIS, Agmark, FSSAI, ISO) in maintaining product quality.

Practicals: **60 hours**

Unit 1: (20 hours)

Testing of quality of milk and water samples: Checking the effectiveness of pasteurization of milk: Alkaline phosphatase test. Detection of microbiological quality of milk sample through Triphenyltetrazolium chloride (TTC) test, Clot on boil (COB) test and dye reduction test (Resazurin). Determination of microbiological quality of water sample by MPN method.

Unit 2: (30 hours)

Microbiological quality of food and pharmaceutical products: Sample processing for detection of microorganisms in food (one solid: Bread/idli batter/cheese/ biscuits/ pizza base/salad/cake etc. and one liquid:juice/ butter milk/ energy drink etc. sample/s.) Detection and Identification of microorganisms present in processed food samples through different types of media (XLD agar/Salmonella-Shigella agar, Mannitol salt agar, EMB agar, McConkey agar). Sterility testing of food (canned food/tetrapak drink) and pharmaceutical products (eye drops/injection ampoule) for aerobic microbes using cultural methods. Demonstration to test the presence of anaerobic microbes by virtual lab/video .Principle and concept of Limulus lysate (LAL) test for detecting the presence of endotoxin in consumable products by virtual lab/video.

Unit 3: (10 hours)

Quality regulation of food and pharmaceutical products: Study of HACCP of milk/dairy product with the help of flow chart. **Student group project**: applications of various standards (BIS, Agmark, FSSAI, ISO) in quality regulation in food and pharma products: case studies involving at least one food and one pharma product.

Suggested Reading (Theory & Practical):

1. Analytical Food Microbiology: A Laboratory Manual by A.E. Yousef, J.G. Waite-Cusic and J.J. Perry. 2nd edition. Wiley Publishers, UK. 2022.
2. Essentials of Pharmaceutical Microbiology by A. Kar, 2nd edition. New Age International. India. 2020.
3. Food Safety and Quality Control by P. Mathur. 1st edition. The Orient Blackswan, India. 2018.
4. Pharmaceutical Biotechnology: Fundamentals and Applications by J.A.D. Crommelin, R. D. Sindelar, and B. Meibohm.(Eds.) 4th edition. Springer, Germany. 2016.
5. Manuals of methods of analysis of foods and water by Food Safety and Standards Authority of India, Ministry of health and family welfare, Government of India, 2016.
   https://old.fssai.gov.in/Portals/0/Pdf/Draft_Manuals/WATER.pdf
   https://old.fssai.gov.in/Portals/0/Pdf/Manual_Fruits_Veg_25_05_2016.pdf
6. Pharmaceutical Microbiology: Essentials for quality assurance and quality control by T. Sandle. 1st edition. Woodhead Publishing. UK. 2015.
7. Fundamentals of Food Microbiology by Bibek Ray and A. Bhunia. 5th edition. CRC Press UK. 2013.
8. Pharmaceutical Biotechnology: Concepts and Applications by G. Walsh. 1st edition. John Wiley & Sons Ltd. USA. 2011.
9. Modern Food Microbiology by J.M. Jay, M.J. Loessner and D.A. Golden. 7th edition. CBS Publishers and Distributors, India. 2006.
10. Handbook of Microbiological Quality control in Pharmaceutical and Medical Devices. R.M Baird, N.A Hodges, and S.P Denyer (Eds) 2nd edition. Taylor and Francis Inc., USA. 2005.
11. Hugo and Russell's Pharmaceutical Microbiology by S.P. Denyer, N.A. Hodges and S.P. Gorman. 7th edition. Blackwell Science. 2004.
12. Microbiological Analysis of Food and Water: Guidelines for Quality Assurance by N.F. Lightfoot and E.A. Maier. 1st edition. Elsevier Science. 1998.
13. Quality control in the Pharmaceutical Industry by M.S. Cooper (Ed). Vol.2. Academic Press,USA.1974.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 4: BIOTECHNIQUES AND INSTRUMENTATION

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical / Practice		
MICROB-DSE 4: **BIOTECHNIQUES AND INSTRUMENTATION**	**4**	**2**	**0**	**2**	**Class XII pass with Biology/ Biotechnology / Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this paper is to develop a strong understanding of the principles and applications of some basic and advanced techniques frequently used in sciences dealing with biological systems. This will allow the students to relate the concepts of the various areas being taught to them with the working and applicability of the instruments and techniques involved.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Will have learnt about the main components, working principles, and applications of different types of microscopes. The student will also be familiarized with the preparation of samples and staining for microscopy.
- Will have gained knowledge of basic concepts, applications, merits and limitations of various bio separation techniques like chromatography, electrophoresis and centrifugation.
- Will be acquainted with the principles and applications of some analytical techniques like X-ray diffraction and UV-visible spectrophotometry. Will have been introduced to the concepts of advanced techniques like circular dichroism, NMR spectroscopy and mass spectrometry.
- Will be able to use the microscope to determine the size of microbial cells applying the technique of micrometry. Will also be able to separate biomolecules using planar (paper chromatography/ TLC) and column chromatography.

- Will have gained hands-on experience of separation of mixtures using gel electrophoresis techniques (PAGE/Agarose) and laboratory centrifuges. Will have gained knowledge of working of density gradient centrifugation with the help of virtual lab / videos.
- Will be able to determine the λmax for an unknown sample and be able to calculate its extinction coefficient using a spectrophotometer. Will get familiar with the technique of autoradiography and NMR spectroscopy with the help of virtual lab / videos.

Theory: **30 hours**

Unit 1: (10 hours)

Principles and applications of microscopy: Concept of resolving power and magnification. Principles, working, and applications of : Bright-field and dark-field microscopy, phase contrast microscopy, fluorescence microscopy, confocal microscopy, electron microscopy (scanning electron microscopy, transmission electron microscopy, and cryo- electron microscopy).

Unit 2: (12 hours)

Principles and applications of separation techniques: Partition chromatography: thin layer chromatography. Column chromatography: gel filtration, ion-exchange, affinity and HPLC. Differential and density gradient centrifugation, ultracentrifugation. Agarose gel electrophoresis. Polyacrylamide gel electrophoresis.

Unit 3: (8 hours)

Principles and applications of other analytical techniques: UV-Visual spectrophotometry (Beer and Lambert Law), X-ray diffraction, circular dichroism, nuclear magnetic resonance (NMR) spectroscopy, mass spectrometry.

Practicals: **60 hours**

Unit 1: (24 hours)

Micrometry and chromatography: Principle of micrometry. Determination of the sizes of different microbial cells by micrometry. Separation of complex mixtures of biomolecules by paper chromatography/ Thin Layer Chromatography. Group project: Packing and running column chromatography. Determination of molecular weight of a protein using gel filtration chromatography.

Unit 2: (20 hours)

Electrophoresis and centrifugation: Separation of DNA by agarose gel electrophoresis. Separation of proteins by SDS-PAGE. Separation of components of a given mixture using a laboratory scale centrifuge using various rotors. Understanding density gradient centrifugation with the help of virtual lab.

Unit 3: (16 hours)

Imaging and advanced analytical techniques: Using spectrophotometer to determine λ_{max} for an unknown sample and calculation of extinction coefficient. Principle and working of autoradiography. Demonstration of autoradiography using virtual lab / video. Understanding NMR spectroscopy with the help of virtual lab / video.

Suggested Reading (Theory & Practical):

1. Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology edited by A. Hofmann and S. Clokie. 8th edition. Cambridge University Press, UK. 2018.
2. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGraw Hill Higher Education, USA. 2019.
3. The Cell: A Molecular Approach by G.M. Cooper. 8th edition. Sinauer Associates, UK. 2018.
4. Lehninger Principles of Biochemistry by D.L. Nelson and M.M. Cox. 7th edition. W.H. Freeman and Company, UK. 2017.
5. Biophysical Chemistry by D. Klostermeier and M.G. Rudolph. 1st edition. CRC press, UK. 2017.
6. Principles of Instrumental Analysis by D.A. Skoog, F.J. Holler and S.R. Crouch. 7th edition. Cengage Learning, USA. 2017.
7. Techniques and Methods in Biology. K. L. Ghatak. PHI Learning Private Limited, India. 2011.
8. Lab Manual in Biochemistry, Immunology and Biotechnology by A. Nigam and A. Ayyagari. Tata McGraw Hill, India. 2007.
9. Physical Biochemistry- Application to Biochemistry and Molecular Biology by D. Freifelder. 2nd edition. W.H. Freemen and Company, USA. 1982.
10. Systems Biology: A textbook by E. Klipp et al. 2nd edition. Wiley-VCH. 2016

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 5: PLANT-PATHOGEN INTERACTIONS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE 5: PLANT-PATHOGEN INTERACTIONS	4	2	0	2	Class XII pass with Biology/ Biotechnology/ Biochemistry	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to provide the students with an overview of the interactions of pathogenic microbes with their host plants, and how these interactions lead to plant disease. The students will become aware of the biochemical basis of plant- pathogen interactions, the production of virulence factors by pathogens, and thei defence mechanisms induced in plants in response to infection.
- They will learn about the genetic basis of disease resistance. They will be able to identify plant pathogens from the symptoms and microscopic study of infected plant specimens.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to explain the important terms related to plant diseases, the scientific contributions of prominent plant pathologists, how microbes attack plants using enzymes, toxins, growth regulators etc., thereby affecting their physiological processes.
- Student will be able to explain describe how plants defend themselves upon attack by pathogens with help of Case studies of some important plant diseases.
- Student will be able to describe the genetics of plant disease and resistance, and developing disease-resistant transgenic plants.

- Student will be able to identify plant pathogens by observing symptoms of diseased plants, cutting sections/ preparing whole mounts of diseased plant material, and observing microscopically.
- Student will be able to explain the etiology, symptoms and control measures of specific bacterial, phytoplasma, virus and viroid diseases with the help of photographs of diseased plants, common disease symptoms observed in locally grown plants during a field visit.
- Student will be able to explain the concept of Koch's postulates using pathogen-infected plant material.

Contents:

Theory: **30 hours**

Unit 1: (5 hours)

Introduction to plant pathology: Concepts and history: Concept of disease and pathogenesis. Causal organisms and symptoms associated with common plant diseases: rust, smut, blight, chlorosis, necrosis, gall, mosaic and wilt. Contributions of the following plant pathologists: E. J. Butler, Anton DeBary, Alexis Millardet, E. Smith, T. O. Diener, E. C. Stakman, J. E. Vanderplank, B. B. Mundkur, J. F. Dastur.

Unit 2: (19 hours)

Physiochemical basis of host-pathogen interactions: Virulence factors of pathogens - Enzymes: pectinases, cellulases. Toxins: host-specific (HV, T-toxin) and non-specific (tabtoxin, tentoxin). Growth regulators: auxin, gibberellin. Virulence factors in viruses: replicase, coat protein, silencing suppressors. Host physiological processes affected by pathogens - photosynthesis, respiration, cell membrane permeability, translocation of water and nutrients, plant growth and reproduction. Defense mechanisms in plants - Inducible structural defenses (histological: cork layer, abscission layer, tyloses,gums), inducible biochemical defenses (hypersensitive response (HR), systemic acquired resistance (SAR), phytoalexins, pathogenesis-related (PR) proteins). Study of some important diseases (etiology, epidemiology, symptoms and control measures): bacterial (crown gall), fungal (black stem rust of wheat), viral (Tobacco mosaic virus, Banana bunchy top).

Unit 3: (6 hours)

Genetics of plant disease resistance: Gene for gene hypothesis: concept of resistance (R) gene and avirulence (avr) gene, the gene for gene hypothesis. Types of plant resistance: true resistance– horizontal and vertical, apparent resistance-disease escape, disease tolerance. Genetic engineering for disease resistance in plants: with plant-derived genes and pathogen-derived genes.

Practicals: **Duration: 60 hours**

Unit 1: (24 hours)

Identification of plant pathogens examining infections microscopically: Principle and working method of lactophenol cotton blue staining. Preparation of whole mount of plant material, followed by staining with lactophenol cotton blue and microscopic observation for identification of the pathogen. Cutting fine transverse sections of infected plant material, staining with lactophenol cotton blue and observing the slide microscopically for identification of the pathogen. Any four from: *Albugo/ Puccinia/ Ustilago/ Phytophthora/ Fusarium/ Peronospora.*

Unit 2: (24 hours)

Study of plant diseases: Study of the etiology, symptoms and control measures of the following diseases. Bacterial: angular leaf spot of cotton, citrus canker. Phytoplasma: aster yellow, citrus stubborn. Viral: rice tungro disease, papaya ring spot, leaf curl of tomato. Viroid: potato spindle tuber, coconut cadang cadang disease. Field visit to a local park/college garden, to study common plant disease symptoms in plants. Recording observations in files with photographs of the diseased plants. **Study research study project**: History, etiology, symptoms, control measures, and economic impact if any, of any four rare plant diseases.

Unit 3: (12 hours)

Demonstration of Koch's postulates using a fruit/ vegetable infected with a plant pathogen: Observation of symptoms, isolation of pathogen by inoculation on potato dextrose agar plates, microscopic identification of the pathogen. Reinoculating it on a healthy fruit/vegetable to observe for similar symptoms, followed by reisolating it and observing microscopically in order to prove Koch's postulates.

Suggested Reading (Theory & Practical):

1. Fundamental of Plant Pathology Practical Manual by S. Singh, A. Kumar, A.K. Mishra. 1st edition. Deepika Book Agency, India. 2021.
2. Practical lab manual for Microbiology and Plant pathology by Huma Naaz, Hadi Husain Khan, Chandan Kumar Singh. 1st edition. AkiNik Publications, India. 2018.
3. Plant Diseases by R.S. Singh. 10th edition. MedTech, India. 2017.
4. Introduction to Principles of Plant Pathology by R.S. Singh. 5th edition. MedTech, India.2017.

5. Plant Pathology by R.S. Mehrotra and A. Aggarwal. 3rd edition. Tata McGraw-Hill Education, India. 2017.

6. Diseases of Crop Plants in India by G. Rangaswami and A. Mahadevan. 4th edition. Prentice Hall, India. 2005.

7. Plant Pathology by G. N. Agrios. 5th edition. Elsevier Academic Press, USA. 2005.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 6:
BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE 6: BIOSAFETY AND INTELLECTUAL PROPERTY RIGHTS	4	2	0	2	Class XII pass with Biology/ Biotechnology/ Biochemistry	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of the course is to introduce students to the fundamental aspects of biosafety and Intellectual Property Rights (IPR) to enable them to understand concerns related to safety from biological hazards and to gain an overview of the biosafety regulatory framework.
- They will be introduced to the importance of protecting intellectual property and become familiar with all aspects of the IPR Acts. Through case studies in law and scientific research students will understand the applications of the legal concepts in the space of scientists, scientific discoveries and innovations.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to describe how national and international biosafety regulations are formulated and implemented at the level of research institutes and laboratories locally, so as to safeguard the handlers as well as the environment from potential pathogens.
- Student will be able to describe the role of an IBSC in the biosafety regulatory framework and how to file an application seeking approval of a research proposal involving an LMO.

- Student will be able to explain the guidelines and precautions that need to be followed during the handling of radioisotopes, the concepts of Intellectual Property Rights, how they are protected through patents.
- Student will be able to demonstrate how to file a patent application. Student will be able to explain some International Agreements, Treaties and Acts governing protection of IPR.
- Student will be able to discuss the basic concepts of protection of IP through Copyright, Trademarks, Geographical indications, Industrial designs, Traditional Knowledge and New Plant Varieties along with specific biotechnological cases.

Contents:

Theory: **30 hours**

Unit 1: (12 hours)

Biosafety: Biosafety levels and risk groups. Role of Institutional Biosafety Committees (IBSC). GMOs/LMOs: Concerns and Challenges. GRAS microorganisms. Risk Analysis, and Assessment for Environmental release of GMOs, Cartagena Protocol. AERB/RSD/RES guidelines for using radioisotopes in laboratories and precautions to be taken.

Unit 2: (12 hours)

Intellectual Property Rights and its types: Introduction and need for intellectual property rights (IPR). Patents: Types of inventions protected by a patent. Prior art search, patent applications and its types, patenting process. Patent infringement, Rights and Duties of patent owner. Patent Publications. Trade secrets and know-how agreements. Budapest Treaty on international recognition of the deposit of microorganisms. Patenting life: legal protection of biotechnological inventions-World Intellectual Property Rights Organization (WIPO) TRIPS, compulsory licensing, Patent Co-operation Treaty (PCT)

Unit 3: (6 hours)

Copyrights, Trademarks, Geographical indications, Industrial designs and New Plant Varieties and Traditional knowledge: Concepts, need, coverage and duration. Commercializing Biotechnology Invention. Case studies of Biotechnology.

Practicals: **60 hours**

Unit 1: (24 hours)

Biosafety levels and guidelines: Study of the layout and design of BSL-1, BSL-2, BSL-3 and BSL-4 laboratories and precautions to be followed according to the level of containment. Filing applications for approval from the Institutional Biosafety Committee (IBSC). **Student group project**: the emergence of biotechnology as the most important tool used to combat the Covid19 pandemic, biosafety protocols in handling Sars-CoV2.

Unit 2: (16 hours)

Genetically Modified Organism: Designing a suitable strategy to protect a genetically modified organism. Case study of the release of GMO Bt Cotton. Status of Bt brinjal and GM mustard in India.

Unit 3: (20 hours)

Patent applications and related case studies: The procedure for filing a patent application. Case study of patenting of basmati rice (GI). Case study of turmeric/ neem (traditional knowledge). **Student group project**: Preparation of patent application

Suggested Reading (Theory & Practical):

1. Intellectual Property Rights in India by P. Saidaiah and K. Ravinder Reddy. International Books and Periodical Supply Service, India. 2020.
2. The Blessing and Curse of Biotechnology: A Primer on Biosafety and Biosecurity, article by R. Langer and S. Sharma. https://carnegieendowment.org/2020/11/20/blessing-and-curse-of-biotechnology- primer-on-biosafety-and-biosecurity-p. 2020.
3. Intellectual Property Rights at a Glance by P. Singh and R.Singh. Daya Publishing House, New Delhi. 2018.
4. Biological Safety: Principles and Practices by D.P. Wooley and K.B. Byers. 5th edition. ASM Press, USA. 2017.
5. Fundamentals of Intellectual Property Rights: For Students, Industrialist and Patent Lawyers by B. Ramakrishna and H.S. Anil Kumar. 1st edition. Notion Press, India. 2017.
6. Biotechnology and Intellectual Property Rights: Legal and Social Implications by K. K Singh. Springer, India. 2015.

7. IPR, Biosafety and Bioethics by D. Goel and S. Parashar. 1st edition. Pearson Education, India. 2013.

8. Law Relating to Patents, Trade Marks, Copyright, Designs and Geographical Indications by. B.L.Wadehra. Universal Law Publishing, India. 2004

9. Encyclopedia of Ethical, Legal and Policy issues in Biotechnology edited by T. M Murrayand M.J. Mehlman. John Wiley and Sons, UK. 2000.

10. http://shodhganga.inflibnet.ac.in/bitstream/10603/205165/7/chapter%20iii.pdf

11. https://dbtindia.gov.in/regulations-guidelines/regulations/biosafety-programme

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 7:
APPLICATIONS OF MICROBES IN BIOREMEDIATION AND PETROLEUM INDUSTRY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE 7: APPLICATIONS OF MICROBES IN BIOREMEDIATION AND PETROLEUM INDUSTRY	**4**	**2**	**0**	**2**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this paper is to provide students with a comprehensive understanding of the process of bioremediation, its strategies, and the role played by microorganism in dealing with environmental pollutants of concern.
- This course highlights the applications of microbes in Microbial Enhanced Oil Recovery (MEOR), clean-up of oil spills, and the detoxification of heavy-metal contaminated environment. Students will acquire hands-on training in the above-mentioned areas.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to explain the concepts of microbial bioremediation, its strategies and its applications, the microbiology of oil fields,Microbial Enhanced Oil Recovery (MEOR) and role of microbes in cleaning up of oil-spills.
- Student will be able to describe the use of biosensors in detection of heavy metals, explain heavy metal tolerance in microorganisms and the application of microbes in the detoxification of such contaminated sites.
- Student will be able to demonstrate the practical skills to isolate hydrocarbon-degrading microorganisms and assess their degradation potential.
- Student will be able to demonstrate how to detect and screen biosurfactant-producing microorganisms in the laboratory.

- Student will be able to demonstrate the isolation of heavy metal tolerant microorganisms, and discuss with case-studies on Microbial Enhanced Oil Recovery.

Contents:

Theory: **30 hours**

Unit 1: (12 hours)

Microbes and Bioremediation: Concept of bioremediation. Abiotic and biotic factors affecting bioremediation by microorganisms. *In-situ* bioremediation strategies: Biosparging, Bioventing, Bioslurping, Biostimulation, Bioaugmentation, and Bioattenuation. *Ex-situ* bioremediation techniques: Bioreactor, Biopiling, Landfarming, composting and Biofilters. Use of genetic engineered microorganisms (GEMs). Advantages, disadvantages and applications of bioremediation.

Unit 2: (12 hours)

Bioremediation of oil spills and microbial enhanced oil recovery: Microbiology of oil fields: introduction to oil fields, formation of oil reservoirs, oil production, indigenous microbial communities in oil fields. Hazards of petroleum hydrocarbon contamination. Microbial degradation of petroleum hydrocarbons (aliphatic, alicyclic, aromatic). Abiotic and biotic factors affecting the degradation of petroleum hydrocarbons. Strategies used to clean up oil spills using microorganisms. Applications of microbial consortia and oil-eating superbugs in bioremediation. Enhanced oil recovery (EOR) versus Microbial Enhanced Oil Recovery (MEOR) Microorganisms and microbial products used in MEOR (biomass, bio- surfactants, biopolymers, solvents, acids, and gases). Technologies used in *ex-situ and in - situ* MEOR applications.

Unit 3: (6 hours)

Heavy metal remediation by microbes: Sources and hazards of heavy metal pollution (As, Cu, Pb, Cd, Hg). Metal-microbes interaction and heavy metal tolerance by microorganisms. Applications of microbes in biosorption and detoxification of environment contaminated with heavy metal(s). Use of biosensors in detection of heavy metal contamination.

Practicals: **60 hours**

Unit 1: (20 hours)

Isolation and detection of hydrocarbon-degrading microorganisms: Sample collection from an oil - contamination site, enrichment, isolation on a suitable minimal medium containing petroleum hydrocarbon, identification of isolates by suitable staining and microscopic observation. Detection of hydrocarbon degradation by the isolates using the redox dye Dichlorophenol-indophenol (DCPIP)**.**

Unit 2: (20 hours)

Detection and screening of bio-surfactant producing microorganisms: Detection of biosurfactant production by hydrocarbon-degrading microorganisms using oil spread method. Screening and selection of the biosurfactant-producing microbes by the following hydrophobicity tests: (1) Drop-collapse method using positive control (Tween-80) and negative control (distilled water) (2) Toluene test (spectrophotometric measurement) and (3) by hydrophobic interaction column chromatography (using Octyl-Sepharose resin).

Unit 3: (20 hours)

Isolation of heavy metal-tolerant microorganisms and case-studies: Sample collection from potential heavy metal-contamination sites (soil/sewage/water bodies/mines), isolation on minimal medium with increasing concentrations of the heavy metal, identification of isolate by suitable staining and microscopic observation. Screening of the isolates for their metal tolerance in broth cultures containing heavy metals. Case studies on *ex-situ* and *in-situ* Microbial Enhanced Oil Recovery by discussions and with the help of visual aids.

Suggested Reading (Theory & Practical):

1. Brock Biology of Microorganisms by M. T. Madigan, K.S. Bender, D.H. Buckley, W.M. Sattele and D. A. Stahl 16th edition. Pearson, USA. 2021.
2. Microbiology: A Lab Manual by J. G. Cappuccino and C. T. Welson. 12th edition. Pearson. 2020.
3. Waste Water Microbiology by D. H. Bergey. 2nd edition. MedTech, India. 2019.
4. Practical Environmental Bioremediation: The Field Guide by R. B. King, J. K. Sheldon and G.M. Long. 2nd edition. CRC Press, USA. 2019.
5. Prescott's Microbiology by J.M. Willey, K. Sandman and D. Wood. 11th edition. McGraw Hill Higher Education. USA. 2019
6. Soil Microbiology by N. S. Subba Rao. 5th edition. MedTech, India. 2017
7. Environmental Microbiology by I. L. Pepper, C. P. Gerba and T.J. Gentry. (Ed). 3rd edition. Academic Press, USA. 2014.
8. Environmental Microbiology of Aquatic and Waste Systems by N. Okafor. Springer, USA. 2011.
9. Advances in Applied Bioremediation by A. Singh, R. C. Kuhad and O. P. Ward. Springer- Verlag,

Germany. 2009.

10. Environmental Microbiology: A Laboratory Manual by I. L. Pepper and C. P. Gerba 2nd edition. Elsevier Academic Press, USA. 2004.
11. Microbial Ecology: Fundamentals and Applications by R. M. Atlas and R. Bartha. 4th edition. Benjamin Cummings, USA. 2000.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 8: SCIENTIFIC WRITING AND COMMUNICATION

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE 8: SCIENTIFIC WRITING AND COMMUNICATION	4	2	0	2	Class XII pass with Biology/ Biotechnology/ Biochemistry	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to familiarize the students with the basic principles of science writing and communication. Students will become aware of databases and tools for effective writing and will be empowered to take up careers as research analysts, technical writers, editors of journals and books etc. They will gain insights into the process of scientific publication. They will learn to effectively communicate science to the masses.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to demonstrate how to carry out a literature search, and explain various types of scientific writings, structure of scientific manuscript and study design.
- Student will be able to describe various types of journals, the concept of impact factors, steps in publication, and software to detect plagiarism.
- Student will be able to discuss the process of writing grant, and how to communicate effectively on scientific issues
- Student will be able to describe the process of writing research/review articles, the process of presenting scientific data through poster or oral presentation.

Contents:

Theory: **30 hours**

Unit 1: (10 hours)

Scientific literature and study design: Understanding research writing. Conducting literature search, scientific literature databases and gap analysis. Types of contemporary science writing (original research article, review, systematic review, meta-analysis, commentary, and opinion). Structure/outline of a research article. Survey study, questionnaire design, using common statistical tools/software for data analysis and presentation in research articles.

Unit 2: (13 hours)

Publication process: Identifying relevant journals through online tools. Impact factor, H-index, citations, Science Citation Index. Steps of the publication process: preparation of manuscript, textual and graphical abstracts, use of multimedia in scientific writing, editing and proofreading, referencing styles, authorship, ethical requirements in science publication, plagiarism detection tools (URKUND/Turnitin), peer review process, predatory publishers andjournals, open access publication.

Unit 3: (7 hours)

Generating funding for research and elements of communication: Introduction to national (DBT, SERB) and international funding agencies (NIH, Welcome Trust). Basics of grant- writing, and structuring a research proposal for extramural funding.

Practicals: **60 hours**

Unit 1: (15 hours)

Communicating scientific issues to the public: Drafting popular articles (newspaper/ magazines). Multimedia tools for effective writing and communication (creating stories using photos, illustrations, audio, video, animation). Publishing blogs.

Unit 2: (30 hours)

Writing original research / review articles: Drafting abstracts. Hands-on training in the preparation of manuscript text: methods, results, discussion, and conclusion. Presenting data in tables and figures: use of Microsoft Excel. Hands-on training in the use of Mendeley to insert references / citations in an article. Writing a review article based on 10 research papers in 1000 words.

Unit 3: (15 hours)

Presentation of scientific data in conferences/seminars: Designing posters. Training in oral presentations: use of Microsoft Powerpoint. Presenting the research and main findings of recent scientific articles through Journal Club**.**

Suggested Reading (Theory & Practical):

1. Research Methodology and Scientific Writing by C.G. Thomas. 2nd edition. Springer. 2021.
2. Scientific writing and communication by A. Hoffman. 4th edition. Oxford University Press. 2019.
3. Effective writing and publishing scientific papers - Part I: how to get started by D. Kotz and J.W. Cals. 2013. J Clin Epidemiol. 66(4):397.
4. Effective writing and publishing scientific papers - Part II: title and abstract by D. Kotz and J.W. Cals. 2013. J Clin Epidemiol. 66(6):585.
5. Effective writing and publishing scientific papers - Part III: introduction by D. Kotz and J.W. Cals. 2013. J Clin Epidemiol. 66(7):702.
6. Effective writing and publishing scientific papers - Part IV: methods by D. Kotz and J.W. Cals. 2013. J Clin Epidemiol. 66(8):817.
7. Effective writing and publishing scientific papers - Part V: results by D. Kotz and J.W. Cals. 2013. J Clin Epidemiol. 66(9):945.
8. Effective writing and publishing scientific papers - Part VI: discussion by D. Kotz and J.W. Cals. 2013. J Clin Epidemiol. 66(10):1064.
9. Effective writing and publishing scientific papers - Part VII: tables and figures by D. Kotz and J.W. Cals. 2013. J Clin Epidemiol. 66(11):1197.
10. Effective writing and publishing scientific papers - Part VIII: references by D. Kotz and J.W. Cals. 2013. J Clin Epidemiol. 66(11):1198.
11. Effective writing and publishing scientific papers - Part IX: authorship by D. Kotz and J.W. Cals. 2013. J Clin Epidemiol. 66(12):1319.
12. Effective writing and publishing scientific papers - Part X: choice of journal by D. Kotz and J.W. Cals. 2014. J Clin Epidemiol. 67(1):3.
13. Effective writing and publishing scientific papers - Part XI: submitting a paper by D. Kotz and J.W. Cals. 2014. J Clin Epidemiol. 67(2):123.
14. Effective writing and publishing scientific papers - Part XII: responding to reviewers by D. Kotz and J.W. Cals. 2014. J Clin Epidemiol. 67(3):243.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 9: AGRICULTURAL MICROBIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE 9: AGRICULTURAL MICROBIOLOGY	**4**	**2**	**0**	**2**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this paper is to enable students to develop a clear understanding of the importance of microbes in agriculture to enable them to find eco-friendly solutions to agricultural problems.
- Students will get an overview of soil characteristics and the role of microbes and plant-microbe interactions in soil fertility. Students will study about the production and application of different types of commercial biofertilizers, become familiar with microbial biocontrol agents, and gain knowledge of composting, and organic farming. They will gain insights into recent trends in agriculture including agrowaste management and transgenics

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to explain types of soil and its characteristics, important microorganisms involved in mineralization of essential nutrients present in the soil and their significance in agriculture, plant-microbe interactions including symbiotic and asymbiotic associations, the commercial production of biofertilizers and method of composting.

- Student will be able to describe eco-friendly ways to control agricultural pests and pathogens, the mode of action, mass production and field applications of various biocontrol agents.
- Student will be able to discuss the recent trends in agricultural microbiology with reference to agrowaste management, organic farming and transgenic plants.
- Student will be able to demonstrate the isolation and screening of various microbes important in soil fertility (PGPR, VAM), the isolation of microorganisms from commercially available biofertilizers.
- Student will be able to explain the different stages of nodule development in leguminous plant roots and will observe nodule-forming bacteria under the microscope, the antagonistic potential of Trichoderma spp. as biological control agent against other fungi.
- Student will be able to describe composting as one of the ways of agrowaste management, the role of thermophiles in composting and the different enzymes involved in biodegradation, steps of mass production of blue green algae and application of microbes in organic farming/biogas production.

Theory: **30 hours**

Unit 1: (14 hours)

Soil fertility and Biofertilizers: Physical and chemical characteristics of different types of soil. Macro and micronutrients in soil. Role of NPK and biogeochemical cycles in soil fertility. Scope of microbes as biofertilizers and their advantages over chemical fertilizers. Isolation, characteristics, mass production and field applications of biofertilizers- Symbiotic: *Rhizobium, Frankia, Acetobacter diazotrophicus*, *Anabaena,* Mycorrhizal associations with special emphasis on VAM/AM fungi. Asymbiotic**:** Nitrogen-fixing bacteria (*Azospirillum, Azotobacter*), Plant growth promoting rhizobacteria (PGPR). Composting: types, methods, applications.

Unit 2: (8 hours)

Biocontrol agents and Biopesticides: Importance, potential and types of biocontrol agents. Microbes used as biopesticides, their mode of action, and advantages over chemical pesticides. Mass production and field applications of *Bacillus thuringiensis*, *Baculoviruses, Beauveria bassiana*, *Metarhizium anisopliae* and *Trichoderma spp*.

Unit 3: (8 hours)

Recent trends in Agriculture Microbiology: Agrowaste management and its significance: Biofuel, Bioenergy, Animal Feed. Organic farming: types, methods and advantages. Development of transgenic plants: *Agrobacterium*-mediated plant transformations with specific example of Bt cotton.

Practicals: **60 hours**

Unit 1: (28 hours)

Isolation of microbes important in soil fertility: Isolation and screening of plant growth promoting rhizobacteria (PGPR) from soil. Isolation of microbes from commercially available biofertilizers using solid media. Isolation of VAM spores from the soil sample using "Wet-sieving and decanting technique" for spores extraction and observing them under microscope. Study of VAM colonization using temporary slides/photographs.

Unit 2: (16 hours)

Study of microbe interactions in soil: Demonstration of stages of nodule formation in leguminous plant with the help of photographs. Slide preparation of crushed nodule to observe nodule forming bacteria. Study of antagonistic activity of *Trichoderma* sp. against different fungi (any 2) using dual culture plate technique. Test of antagonistic efficacy on potato dextrose agar: simultaneous inoculation of antagonist and test fungus at two extreme positions and recording of zone of inhibition after 5 days of incubation.

Unit 3: (16 hours)

Agrowaste management: Hands-on training in composting using a variety of plant/food waste. Isolation of thermophiles from compost and qualitative assay of any two enzymes (amylase/cellulase/xylanase) using compost sample. Visit to mass production facility of blue green algae/biogas plant/organic farm.

Suggested Reading (Theory & Practical):

1. Benson's Microbiological Applications, Laboratory Manual in General Microbiology by A. E. Brown and H. Smith.15th edition. McGraw-Hill Education, USA. 2022.
2. Biopesticides and Bioagents: Novel tools for pest management by M. A. Anwer. Ist edition. Apple Academic Press, USA. 2021.
3. Bioprocess Technology by P. T. Kalaichelvan and I. A. Pandi. 1st edition. MJP Publishers, India. 2021 (reprint).
4. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition. Pearson Education, USA. 2020.
5. Soil Microbiology by N.S. Subba Rao. 5th edition. Oxford & Ibh Publishing, USA. 2020.
6. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGraw Hill Higher Education, USA. 2019.

7. Biofertilizers in Agriculture and Forestry by N.S. Subba Rao. 4th edition. Medtech. India. 2019.

8. Advances in soil microbiology: recent trends and future prospects by T.K. Adhya, B. Lal, B. Mohapatra, D. Paul and S. Das. Volume 2. Springer, Singapore. 2018.

9. Experiments in Microbiology, Plant Pathology and Biotechnology by K. R. Aneja. 5th Edition. New Age International Publishers, India. 2017.

10. Development of Bioinsecticides by F. Saleem A.R. Shakooori. Lap Lambert Academic Publishing, European Union. 2012.

11. Advanced Environmental Biotechnology by S.K. Aggarwal. 1st edition. APH publication, India. 2005.

12. Biotechnology of Biofertilizers edited by S. Kannaiyan. 1st edition. Springer, Netherlands. 2002.

13. Bioinoculants for Sustainable Agriculture and Forestry by S.M. Reddy. 1st edition Scientific Publishers, India. 2002.

14. Microbial Ecology: Fundamentals and Applications by R.M. Atlas and R. Bartha. 4th edition. Benjamin Cummings, USA. 2000.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 10:
PRINCIPLES OF GENETICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE 10: PRINCIPLES OF GENETICS	**4**	**2**	**0**	**2**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is for students to gain knowledge of the major concepts of genetics. Students will build a foundation for understanding the basic principles of inheritance and heredity starting from classical genetics, and will gain insights into chromosomal behaviour, rearrangements and their consequences.
- Students will also learn about complex multifactorial quantitative genetics and population genetics in relation to survival and evolution. Through this course the students will develop a better understanding of life processes, survival and maintenance.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to explain the laws of inheritance, linkage, crossing over and its application to gene mapping.
- Student will be able to describe the mechanisms for extranuclear inheritance, complex traits and population genetics principles, model organisms of genetic research.
- Student will be able to explain pedigree analysis, aberrations in chromosomal structure and number.
- Student will be able to demonstrate the techniques of karyotyping and chromosome banding, the giant chromosomes.

Theory: **30 hours**

Unit 1: (12 hours)

Introduction to basics of Genetics: History: A brief account of early genetic experiments: Mendel's work. Studying variation: phenotype and genotype. Single gene inheritance pattern: concept of alleles, allelic interactions, autosomal and X-linked inheritance. Concept of segregation, penetrance, expressivity. Test for allelism: complementation. Two- gene inheritance pattern: independent assortment versus linkage. Molecular basis of phenotypic variation and inheritance patterns. Introduction to genetic maps: three point test crosses.

Unit 2: (9 hours)

Extra-nuclear inheritance and epigenetics: Introduction and rules of extra-nuclear inheritance. Organelle heredity: chloroplast mutations in *Chlamydomonas* and *Mirabilis jalapa.* Maternal effect: shell coiling in *Limnaea peregra.* Infectious heredity: Kappa particles in *Paramecium.*

Unit 3: (9 hours)

Quantitative and Population Genetics: Polygenic inheritance, Johannsen pure-line theory, multiple factor hypothesis. Types of quantitative traits, heritability and its measurements. Genetic structure of populations, gene pool, genotype frequencies, allele frequencies. Hardy–Weinberg Law: Assumptions and Predictions.

Practicals: **60 hours**

Unit 1: (30 hours)

A review of model organisms for genetic analysis: **Student group research study**: Organisms for genetic research: *Escherichia coli, Saccharomyces cerevisiae, Neurospora crassa, Drosophila melanogaster, Caenorhabditis elegans, Arabidopsis thaliana, Tetrahymena thermophila*. Case studies highlighting one major biological finding from studies with each of these organisms. Understanding genetic analysis through problem solving: statistical analysis of given genetic data by Chi-Square Analysis.

Unit 2: (20 hours)

Studying inheritance in humans: Pedigree analysis: chromosomes and aberrations through karyotyping and chromosome banding techniques.

Unit 3: (10 hours)

Study of Giant Chromosomes: Polytene and Lampbrush chromosomes. Preparation of temporary mounts of salivary glands of *Chironomus* / *Drosophila* larvae, and their visualization by bright field microscopy. Study of lampbrush chromosomes through permanent mounts.

Suggested Reading (Theory & Practical):

1. Introduction to genetic analysis by A. Griffiths, J. Doebley, C. Peichel and D. Wassarman. 12th edition. Macmillan Learning. 2020.
2. Laboratory Manual for Principles of Genetics by W. Mhiret. Lap Lambert Academic Publishing. 2020.
3. Concepts of Genetics by W.S. Klug, M.R. Cummings, C. Spencer and M. Palladino. 12thedition. Pearson Education, USA. 2019.
4. Genetics: A Conceptual Approach By B. Pierce. 7th edition. W.H. Freeman and Co. 2019.
5. Genetics: Analysis of Genes and Genomes by D. Hartl and B. Cochrane. 9th edition. Jones and Bartlett Learning, USA. 2017.
6. Introducing Epigenetics : A graphic guide by C. Ennis. Icon Books Ltd, India. 2017.
7. iGenetics- A Molecular Approach by P.J. Russell. 3rd edition. Pearson Education India. 2016.
8. Principles of Genetics by D. Snustad and M. Simmons. 7th edition. Wiley and Sons, UK. 2015.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 11: MICROBIAL BIOTECHNOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE 11: **MICROBIAL BIOTECHNOLOGY**	**4**	**2**	**0**	**2**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to give students an overview of the beneficial role of microbial biotechnology in the welfare of humankind. They will learn about harnessing the power of microorganisms to manufacture medicinal, industrial, and agricultural products.
- Students will be acquainted with the large-scale culturing of microorganisms to produce various metabolites at a commercial scale. Students will gain hands-on experience in screening samples for enzyme and pigment producers and dye degrading microorganisms. They will learn to immobilise enzymes and cells and use enzyme-based biosensors for analytical purposes.
- The students will get conversant with applications of bioremediation and the protection of intellectual property rights.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to describe the emerging biotechnology industries at the national and international level, use of microbe-based technologies and innovations for the benefit of mankind.
- Student will be able to explain the potential use of high-yielding microorganisms to commercially produce human therapeutics and industrial products, biosensors and steroid biotransformation.

- Student will be able to describe how microorganisms are utilized for the industrial production of biofertilizers and biopesticides, their potential use in environmental pollution management.
- Student will be able to demonstrate immobilization of biocatalysts (whole cells/enzymes) and explain how this technology can find applications in large-scale enzymatic reactions, bioremediation and designing of biosensor-based kits.
- Student will be able to explain the screening of environmental samples to isolate organisms with desired properties (enzyme production, pigment production, dye degradation).
- Student will be able to describe the research work involving GMOs and approvals required thereof and will appreciate the importance of protecting Intellectual Property Rights.

Theory: **30 hours**

Unit 1: (4 hours)

Microbial Biotechnology as an emerging Industry: Global Biotechnology industries and their products. Biotechnology trends in India with particular reference to our country's premier biotechnology institutes and industries and their products : Biocon, Serum Institute of India, Bharat Biotech and Hindustan Antibiotics Ltd. Innovations and Startups based on Microbial Biotechnology. Biotechnology in mass production of valuable products using microorganisms and advantages of using microorganisms (Laboratory, pilot and industrial- scale bioreactors).

Unit 2: (14 hours)

Microbial Biotechnology in the development of human therapeutics and industrial products: Prokaryotes and eukaryotes as expression hosts for heterologous proteins. Microbial production of therapeutic recombinant products: hormones (insulin, human growth hormone), thrombolytic agents (streptokinase and tPA) and vaccines (Hepatitis B and Covid-19 vaccines). Industrial bulk products: Production of microbial polysaccharides (xanthan gum and agar-agar), bioplastics (PHB), food-grade pigments/colorants (phycocyanin and Beta-carotene/lycopene), high fructose corn syrup. Development and functioning of enzyme- based biosensors (GOD and cholesterol oxidase). Microbial transformation of steroids**.**

Unit 3: (12 hours)

Role of Microbial Biotechnology in agriculture and environment management: Biofertilizers: liquid and carrier-based biofertilizers. Mass production of *Rhizobium, Acetobacter diazotrophicus, Azotobacter sp*. Commercial production of Biocontrol agents (*Bacillus thuringiensis* & *Trichoderma harzianum*). Development of transgenic crops with particular emphasis on insect resistance, viral resistance and nutritional quality enhancement (Bt-brinjal, Roundup-ready crops and golden rice). RNAi and its application in crop improvement. Edible vaccines, synthetic meat and Single Cell Protein (*Spirulina* & *Fusarium graminearum*), biodiesel production (algal biofuel).

Microbial bioremediation of oil spills using genetically modified organisms (GMOs) and microbial consortia. Microorganisms in the removal of heavy metals from aqueous effluents and copper bioleaching.

Practicals: **60 hours**

Unit 1: (18 hours)

Immobilization of enzymes, cells and biosensors: Immobilization of yeast cells (*Saccharomyces cerevisiae*) by entrapment using calcium alginate beads/agarose/agar and determination of the invertase activity of the immobilized cells by carrying out an invertase assay. Immobilization of an enzyme (amylase/urease/invertase) using calcium alginate/ agarose/ agar and study of its long term storage stability using enzyme assays. Use of an enzyme-based biosensor (glucose oxidase/glucose-1-dehydrogenase based devices to monitor glucose uptake/consumption during a fermentation; cholesterol oxidase/beta- hydroxybutyrate dehydrogenase-based kits to monitor changes in levels of the substrate over a period of time).

Unit 2: (30 hours)

Screening for enzymes and pigment-producer / dye-degrading microorganisms, and expression of a cloned gene: Primary screening of soil samples to isolate microorganisms that produce hydrolytic enzymes (any one): amylase, protease, lipase, CM cellulase, xylanase. Isolation of pigment-producing microorganisms from the environment and laboratory-scale production of any pigment using the shake-flask technique OR Screening for dye-degrading (methylene blue/ methyl orange/ Rhodamine B, etc.) microorganisms from the environment using plate assays and study of the absorption spectra of any dye. Transformation and expression studies of a given plasmid (expressing Green Fluorescent Protein) in the BL21 strain of *E coli,* analysis of protein expression using SDS-PAGE.

Unit 3: (12 hours)

An orientation to the biosafety regulatory framework for Genetically Modified Organisms (GMOs) in India: An introduction to different methods of protecting Intellectual Property in India (Patents, Copyrights, Trademarks, Geographical Indications, Industrial Design and New Plant Varieties). Filing applications for approval of research proposals by the concerned regulatory bodies. Filing of a patent application to the regulator for the protection of a GMO. **Student group research project:** Case study of any microbial consortium available in India for environmental bioremediation.

Suggested Reading (Theory & Practical):

1. Industrial Microbiology by A.H. Patel. 2nd edition. Laxmi publication Pvt Ltd/Trinity Press. 2022.

2. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition.

Pearson Education, USA. 2020.

3. Industrial Microbiology by L.E. Casida. 2nd edition. New Age International Publisher. 2019.

4. Intellectual Property Rights in India. Pidigam Saidaiah and K. Ravinder Reddy. International Books and Periodical Supply Service. 2020.

5. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGrawHill Higher Education, USA. 2019.

6. Crueger's Biotechnology: A Textbook of Industrial Microbiology by W. Crueger, A. Crueger and K.R.Aneja. 3rd edition. Medtech Publisher, India. 2017.

7. Principles of Fermentation Technology by P.F. Stanbury, A.Whitaker and S.J. Hall. 3rd edition. Elsevier Science Ltd, Netherlands. 2016.

8. Benson's Microbiological Applications: Laboratory Manual in General Microbiology by A.E. Brown and H. Smith. 15th edition. Mc-Graw Hill Education, USA. 2022.

9. Manual of Industrial Microbiology and Biotechnology by R.H. Baltz, A.L.Domain, and J.E. Davies. 3rd edition. American Society for Microbiology. 2010.

10. Molecular Biotechnology by B.R. Glick, J.J. Pasternak and C.L. Patten. 4th edition, ASM Press, USA. 2009.

11. Microbial Biotechnology: Fundamentals of Applied Microbiology by A.N. Glazer and H. Nikaido. 2nd edition. W.H. Freeman and Company, UK. 2007.

12. Manual of Industrial Microbiology and Biotechnology by A.L. Demain, J.E. Davies and R.M. Atlas. 2nd edition. ASM Press, USA. 1999.

13. The DBT portal: https://dbtindia.gov.in/regulations-uidelines/regulations/biosafety- programme

14. Intellectual Property Rights: Chapter III on the INFLIBNET portal: http://shodhganga.inflibnet.ac.in/bitstream/10603/205165/7/chapter%20iii.pdf

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 12: RESEARCH METHODOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE 12: RESEARCH METHODOLOGY	4	2	0	2	Class XII pass with Biology/ Biotechnology/ Biochemistry	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of the course is to give the students a broad understanding about research approaches and tools, and importantly, an ability to deploy them in their degree programme.
- This will impart skills for critical reading of research literature, various research methods, including theory of scientific research and qualitative and quantitative methods and for developing a research proposal. The course will outline all the fundamentals of carrying out research in an ethical manner.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to explain the basics of research and hypothesis formulation, the different approaches of doing research, acquiring data, and performing data analysis.
- Student will be able to describe the process of scientific writing and presenting of research data.
- Student will be able to demonstrate the process of effective literature search and writing a review.
- Student will be able to analyse datasets and present them through tables, charts and graphs.
- Student will be able to describe the process of writing proposals for research grants.

Contents:

Theory **30 hours**

Unit 1: (8 hours)

Foundation of research and research ethics: What is research, benefits of research. Selection of research topic. Effective literature search. Problem identification and hypothesis building. Qualities of a good hypothesis, hypothesis testing, null hypothesis and alternative hypothesis, logic and importance. Ethics in research: indices for scientific rigor, honesty and integrity, respect for intellectual property, responsible publication of data.

Unit 2: (14 hours)

Approaches to research and research methods: Basic and applied research, descriptive and analytical research, quantitative and qualitative research, experimental and non-experimental research. Good laboratory practices (GLP): Standard Operating Procedures, Biosafety, Radiation safety. Experimental Design. Concept of Experiment Controls. Concept of independent and dependent variables. Recording experimental protocol and data in lab notebooks, preparation for experiments. Field experiments: sampling, types of sampling studies, characteristics of a good sample, sampling frame, sample size, sampling error, scales of measurement, double blind studies. Data analysis and representation: Use of Excel for tables and charts, Common statistical tests (hypothesis of association, student t test) and introducing popular

statistical packages.

Unit 3: (8 hours)

Research Communication: Knowledge dissemination. Effective presentation in scientific conferences (Poster/oral). Structure of research paper. Structure of a thesis/dissertation. Software for scientific paper formatting (LaTeX/MS Office). Software for management of references (Mendeley/Endnote). Software for image processing. Choosing a journal for publication. Impact factor of journals. Ethical issues related to publishing, plagiarism, software for detection of plagiarism.

Practicals: **60 hours**

Unit 1: (20 hours)

Literature Search and Review: General Search Engines, Bibliographic Databases, Digital Libraries, Types of publications, literature search on a given topic and writing a review.

Unit 2: (20 hours)

Analysis and presentation of given dataset: Training in the use of Microsoft Excel for data presentations in tables, graphs and charts. Training in the use of Microsoft Powerpoint for presenting scientific findings at meetings/conferences. Writing an Abstract for paper/conference based on given data.

Unit 3: (20 hours)

Planning and writing a research proposal: General considerations, finding a research problem. Major Funding agencies in India. Mandate of the call for proposals. How to write a proposal. **Student group project**: writing a research proposal on a given topic

Suggested Reading (Theory & Practical):

1. Research Methodology for Natural Sciences by S. Banerjee. I.I.Sc. Press, India. 2022.
2. Research Methodology and Scientific Writing by C.G. Thomas. 2nd edition. Ane Books, India. 2019.
3. Scientific writing and communication by A. Hoffman. 4th edition. Oxford University Press. 2019.
4. Research Methodology: Methods and Techniques by C.R. Kothari. 4th edition. New Age International Publishers, India. 2019.
5. Testing treatments: Better research for better healthcare by I. Evans, H. Thornton, I. Chalmers and P. Glasziou. 2nd edition. Pinter & Martin Ltd, UK. 2013.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 13:
Applications of Informatics in Biology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE 13: **Applications of Informatics in Biology**	**4**	**2**	**0**	**2**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this paper is to enable the students to develop a clear understanding of the various concepts and applications of bioinformatics, a field which encompasses diverse applied disciplines such as molecular biology, genomics, proteomics, transcriptomics and systems biology. Students will also learn applications of artificial intelligence in bioinformatics.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to explain the goals of bioinformatics and its applications, diverse types of biological databases, concept and significance of sequence alignment, phylogeny, types of phylogenetic trees.
- Student will be able to describe the diversity of viral, prokaryotic, eukaryotic genomes and their organization, proteomics along with the details of structure of proteins, protein structure prediction, and energy minimizations.
- Student will be able to explain the significance of artificial intelligence and machine learning in various biological applications, computer-aided drug discovery, epitope prediction and its significance in vaccine development and allergen prediction.
- Student will be able to demonstrate how to work with biological databases, similarity searches, sequence alignments and phylogenetic analysis.

- Student will be able to demonstrate working with databases and analysis, gene prediction and other features, and primer designing.
- Student will be able to demonstrate how to identifying secondary structural features of proteins, prediction of protein structure models from amino acid sequences, molecular docking and epitope prediction.

Contents:

Theory: **30 hours**

Unit 1: (10 hours)

Fundamentals of bioinformatics, sequence alignment and phylogeny: Aims and scope of bioinformatics. Concepts of genome, transcriptome, proteome, systems biology, metabolome, interactome and neural network. Biological databases and types. Sequence similarity and Sequence alignment (Local and Global Sequence alignment), pairwise and multiple sequence alignment. Phylogeny, rooted and unrooted trees.

Unit 2: (10 hours)

Genomics and Proteomics: Features of the viral, prokaryotic (*E. coli*) and eukaryotic (human) genomes. Gene Ontology, Hierarchy, and features of protein structure, Structural classes, motifs, folds and domains. Homology modelling of tertiary structure of protein, Molecular dynamic simulations and energy minimizations, Evaluation by Ramachandran plot.

Unit 3: (10 hours)

Artificial Intelligence in bioinformatics: Role of AI and machine learning in biology (proteomics, structural biology, disease management, drug discovery and genomics). Computer-aided drug discovery and design. Bioinformatics in epitope mapping for vaccine design and allergen prediction.

Practicals: **60 hours**

Unit 1: (24 hours)

Biological Databases, similarity search, sequence alignments and phylogenetic analysis: Study of bioinformatics databases, File formats: FASTA, GenBank. Sequence submission tools: NCBI, PDB. Sequence retrieval and similarity search using BLAST, Multiple sequence (DNA/Protein) alignment using CLUSTAL omega. Phylogenetic analysis using MEGA.

Unit 2: (16 hours)

Identification and analysis of genome features: Picking out a given gene from genomes using

GENSCAN or other software (promoter region identification, repeats in the genome, ORF prediction, Gene finding tools), Genome browsing using Ensemble/Genome Data Viewer (NCBI) for features of E. coli and Human Genome (Search a genomic assembly to display a region annotated with a particular gene), Design and analysis of PCR primers using PRIMER BLAST or any other tool.

Unit 3: (20 hours)

Protein structure prediction and evaluation, molecular docking, epitope prediction: Primary structure analysis. Secondary structure prediction using psi-pred. Molecular visualization using JMOL/PyMOL, protein structure model evaluation, virtual screening of drugs using AUTODOC-VINA/ any other software, Demonstration of IEDB (https://www.iedb.org) server for the prediction of HLA class I and II binding epitopes.

Suggested Reading (Theory & Practical):

1. Bioinformatics: Tools and Techniques edited by L. Baker. 1st edition. Callisto. 2018.
2. Applied Bioinformatics: An Introduction by P. Selzer, R. Marhöfer and O. Koch. 2nd edition. Springer, USA. 2018.
3. Bioinformatics Techniques for Drug Discovery: Applications for Complex Diseases by A. Kaushik, A. Kumar, S. Bharadwaj and R. Chaudhary. 1st edition. Springer International, UK. 2018.
4. Foundations of Computing by P. Sinha and P.K. Sinha. 6th edition. BPB Publications, India. 2017.
5. Basic Applied Bioinformatics by C. Mukhopadhyay, R. Choudhary and M.A. Iquebal. 1st edition. Wiley-Blackwell, USA. 2017.
6. Bioinformatics: Principles and Applications by Z. Ghosh and V. Mallick. 1st edition. Oxford University Press, India. 2015.
7. Introduction to Bioinformatics by M.Lesk. 4th edition. Oxford Publication, UK. 2014.
8. Bioinformatics: methods and applications, genomic, proteomics and drug discovery by S. Rastogi, N. Mendiratta and P. Rastogi. 4th edition. Prentice Hall India Publication. 2007.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 14: ADVANCES IN MICROBIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE 14: ADVANCES IN MICROBIOLOGY	**4**	**2**	**0**	**2**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to educate students about the latest developments in the field of microbiology and apprise them of the cutting-edge technologies being used for research and development.
- They will learn the uses of omics approaches, meta-omics, systems biology, and synthetic biology. They will become familiar with the development and applications of CRISPR-Cas technology and will gain insights into the versatile field of microbial nanotechnology.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to discuss the host-microbe arms race, newer methods to combat challenges of antimicrobial resistance and biofilms, the use of meta-omics approaches in research, latest cutting-edge technology of CRISPR-Cas and its applications.
- Student will be able to explain the Systems and Synthetic Biology and their applications; the principles, techniques, and applications of the versatile field of nanobiotechnology.
- Student will be able to demonstrate soil metagenomics and PCR-based taxonomy analysis, and describe major metagenomics projects worldwide through case studies.
- Student will be able to demonstrate synthesis and testing of silver nanoparticles with antimicrobial properties from plant, fungal/bacterial

extracts; and explain about the analytical research tools to characterize the nanoparticles.

- Student will be able to describe Poliovirus synthesis, mRNA vaccine synthesis and Genome synthesis of mycoplasma through case studies.

Contents:

Theory: 30 hours

Unit 1: (10 hours)

Host- microbe interactions and use of microbes in healthcare: Host-Microbe arms race, genome- pathogenicity islands, Type Three Secretion System (T3SS), Quorum Sensing, and Biofilm formation in bacteria. Viral zoonosis and pandemics. Gene for Gene hypothesis, hypersensitive response, plant resistance genes, and signal transduction mechanism. Addressing the challenges of Anti-Microbial Resistance (AMR) and biofilms by phages, and of cancer through oncolytic viruses.

Unit 2: (10 hours)

Modern molecular techniques in Microbiology: Meta-Omics technology (Metagenomics, Metatranscriptomics, Metaproteomics, and Metabolomics): Principles, techniques deployed, and applications. CRISPR-Cas technology- History, mechanism, applications (in Health, Agriculture and other Industries) and limitations of this technology.

Unit 3: (10 hours)

Systems biology, Synthetic biology, and Nanobiotechnological Approaches in Microbiology: Systems biology approach for holistic perspectives and better outcomes. Types of Biological Networks. Cell signaling and interaction networks. Synthetic biology: principles and applications. Concept, methodology, and applications of Microbial Nanotechnology in health, agriculture, and food industry. Applications of Viral and Viral-like Nanoparticles.

Practicals: 60 hours

Unit 1: (20 hours)

Metagenomic technique to study soil microorganisms: Hands-on training in extraction of DNA from soil, and PCR amplification of metagenomic DNA using universal16S ribosomal gene primers. **Student group project:** Research and review on major metagenomic projects (Sargasso Sea Project, Viral Metagenomics and Human Microbiome Project)

Unit 2: (25 hours)

Synthesis and analysis of silver nanoparticles from plants extracts and microbes (fungi/bacteria). Hands-on training in synthesis of silver nanoparticles by any one method. Testing of antimicrobial properties of synthesized silver nanoparticles. Characterization of nanoparticles by UV-vis Spectroscopy, X-ray Diffraction (XRD), Scanning and Transmission Electron Microscopy (SEM and TEM) through virtual labs / videos. Visit to Sophisticated Instrumentation Facility of a research institution.

Unit 3: (15 hours)

Student research study project: Poliovirus Synthesis: a case study to understand how the poliovirus was synthesized in the laboratory. mRNA-Vaccine Synthesis: a case study of the steps involved in synthesis of mRNA vaccine and testing its efficacy. **Student group project**: Covid19 mRNA vaccines in the market in India and overseas. Genome synthesis of mycoplasma: a case study to develop a synthetic genome of mycoplasma.

Suggested Reading (Theory & Practical):

1. Brock Biology of Microorganisms by M.T. Madigan, and J.M. Martinko. 16th edition. Pearson., USA. 2021.
2. Microbiomes: Current Knowledge and unanswered Questions by E. Rosenberg. Springer Nature, Switzerland. 2021.
3. An Introduction to Systems Biology: Design, Principles of Biological Circuits by Uri Alon, 2nd edition. CRC Press. 2020.
4. Antimicrobial Resistance: Global Challenges and Future Interventions edited by Sabu Thomas. Springer. 2020.
5. Biological Synthesis of Nanoparticles and Their Applications, by L. Karthik, A. Vishnu Kirthi, S. Ranjan, V. M. Srinivasan. CRC Press, Taylor and Francis, USA. 2020
6. Genomic Engineering via CRISPR-Cas 9 system edited by Vijay Singh and Pawan K. Dhar. Academic Press. 2020
7. Microbial Nanotechnology edited by M. Rai and Golinsky P. CRC Press. 2020
8. Bacterial Pathogenesis: A Molecular Approach by B.A. Wilson, A.A. Salyers, D. D. Whitt, and M.E. Winkler. 4th edition. ASM Press, USA. 2019.
9. Implications of Quorum Sensing and Biofilm formation in Medicine, Agriculture and Food Industry by P. V. Bramhachari. Springer. 2019.
10. Nanotechnology in Food: Concepts, Applications, and Perspective by H.J. Malmiri. Springer. 2019.
11. Quorum Sensing: Molecular Mechanism and Biotechnological Applications by G. Tommonaro. Academic Press, USA. 2019.
12. Agricultural Nanobiotechnology: Modern Agriculture for a Sustainable Future by F. Lopez-Valdez and F. Fernandez-Luqueno. Springer. 2018.

13. Implications of Quorum Sensing System in Biofilm Formation and Virulence by Bramhachari. Springer. 2018.
14. Nanobiotechnology: Human Health and the Environment by A. Dhawan, S. Singh, A. Kumar, and R. Shanker (editors). CRC Press, USA. 2018.
15. Synthetic Biology: Omics Tools and their Applications by Shailza Singh. Springer. 2018
16. Viral Metagenomics: Methods and Protocol by V. Pantaleo and M. Chiumenti. Springer Protocols. Humana Press. 2018.
17. Virus Derived Nanoparticles for Advanced Technologies-Methods and Protocols by C. Wege and G. Lomonsoff. Humana Press, Springer, USA. 2018.
18. Microbial Biofilms: Omics Biology, Antimicrobials and Clinical Implications by C. J. Seneviratne. CRC Press. 2017.
19. Precision Medicine, CRISPR, and Genome Engineering: Moving from Association to Biology and Therapeutics by S. H. Tsang. Springer. 2017.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 15: MICROBIOME IN HEALTH AND DISEASE

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE 15: MICROBIOME IN HEALTH AND DISEASE	4	2	0	2	Class XII pass with Biology/ Biotechnology/ Biochemistry	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to introduce the human microbiome to students and give them an understanding of its dynamics and function in maintaining homeostasis.
- Students will gain an understanding of the diversity of microbial communities present in various organs in humans. They will gain insights into our current understanding of the impact of microbiome alterations on host health and disease. Students will become aware of techniques used to analyze large omics data sets in investigating microbial communities colonizing humans.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to explain about human microbiome and methods to study microbiomes, the link between human microbiome and diseases
- Student will be able to describe microbiome-based therapeutic approaches and their challenges, human microbiome project and various databases and software for microbiome analysis
- Student will be able to discuss the basic workflow in a typical microbiome study and analyze microbiome data

- Student will be able to describe current knowledge on the role of microbiome in various diseases

Contents:

Theory **30 hours**

Unit 1: (14 hours)

The human microbiome: Understanding microbiome, importance of microbiome research, development of the microbiome. Vertical and horizontal transfer of human microbiomes, source of the organisms in the human microbiome. Diversity in oral, gut, respiratory and skin microbiome. Microbiome-Gut-Brain Axis. Methods to study the human microbiome: DNA-based analysis of microbial communities, 16S rDNA gene amplicon sequencing and whole metagenome shotgun sequencing methods. Data pre-processing and quality control. Microbiome data analysis: clustering and OTU picking, taxonomic analysis, alpha and beta-diversity. Comparing microbial communities: phylogenetic trees, UniFrac, principal coordinate analysis, Venn diagrams, heat maps. Functional and comparative analysis: metatranscriptome, metabolome, metaproteome.

Unit 2: (10 hours)

Microbiome and its relation to health and disease: Dysbiosis, correlation of dysbiosis with disturbance in microenvironment. Dysbiosis in progression of non-communicable diseases such as cancer, Inflammatory Bowel Disease (IBD), obesity, diabetes, Alzheimer's, and incommunicable diseases such as COVID-19, tuberculosis and typhoid. Nutritional modulation of the gut microbiome. Prakriti and gut bacteria: perspective of traditional ayurveda. Microbiome and host immune system interaction. Effect of antibiotics on microbiota, oral dysbiosis and oral diseases, skin microbiome alterations and cutaneous allergic diseases.

Unit 3: (6 hours)

Microbiome-based therapeutic approaches: Maintaining and restoring a healthy microbiome. Additive, subtractive, and modulatory microbiome-based therapies. Health benefits of prebiotics and probiotics. Fecal transplant and its applications. Challenges in the field of microbiome therapeutics. Microbiome-based diagnostics.

Practicals **60 hours**

Unit 1: (20 hours)

Tools and techniques to study microbiome: Human Microbiome project. Hands-on exposure to various databases (NCBI, HOMD) and opensource software related to microbiome analysis (microbiome analyst, QIIME 2.1, galaxy).

Unit 2: (20 hours)

Research strategy and experimental design in a typical microbiome study: Sample collection, DNA extraction, library preparation and DNA sequencing through virtual lab. Data analysis. Comparison of alpha and beta diversity in given data sets. Interpretations of given heat maps.

Unit 3: (20 hours)

Student group research study projects: Current knowledge on the role of microbiome in respiratory health, the impact of the human microbiome on auto-immune diseases, the interplay of bacteria and eukaryotic microbes in the human gut: presentation of the findings and submission of research study report.

Suggested reading (Theory & Practical):

1. Recent Advances in Understanding the Structure and Function of the Human Microbiome by W. Mousa, F. Chehadeh, and S. Husband. *Frontiers In Microbiology*, *13*. doi: 10.3389/fmicb.2022.825338. 2022.

2. *Microbiome-Gut-Brain Axis* by R. Sayyed and M. Khan. Springer, Singapore. 2022.

3. Targeting the Gut Microbiota for Remediating Obesity and Related Metabolic Disorders by B. Wang et al. J Nutr. 151:1703-1716. http://doi: 10.1093/jn/nxab103. 2021.

4. The human microbiome and COVID-19: A systematic review by S. Yamamota. *PloS One* 16;6. doi:10.1371/journal.pone.0253293. 2021.

5. Metagenomics: Techniques, Applications, Challenges and Opportunities by R.S. Chopra, C. Chopra and N.R. Sharma. Springer. 2020.

6. Gut-Brain Axis: Role of Gut Microbiota on Neurological Disorders and How Probiotics/Prebiotics Beneficially Modulate Microbial and Immune Pathways to Improve Brain Functions by K. Uganya and B.S. Koo. *International journal of molecular sciences*, *21*(20), 7551. 2020.

7. The Influence of the Gut Microbiome on Obesity in Adults and the Role of Probiotics, Prebiotics, and Synbiotics for Weight Loss by A. Aoun, F. Darwish and N. Hamod. Prev Nutr Food Sci., 25(2):113-123. doi: 10.3746/pnf.2020.25.2.113. 2020.
8. The gut microbiome in tuberculosis susceptibility and treatment response: guilty or not guilty? by Eribo, O. A., du Plessis, N., Ozturk, M., Guler, R., Walzl, G. and Chegou, N.N. *Cellular and molecular life sciences : CMLS*, *77*(8), 1497–1509. https://doi.org/10.1007/s00018-019-03370-4. 2020.
9. The influence of the microbiome on respiratory health by T.P. Wypych, L. Wickramasinghe and B. Marsland. *Nature Immunology*, *20* (10), 1279–1290. https://doi.org/10.1038/s41590-019-0451-9. 2019.
10. The microbiome, cancer, and cancer therapy by Helmink *et al*. *Nat Med* 25, 377–388. https://doi.org/10.1038/s41591-019-0377-7. 2019.
11. *Metagenomics* by M. Nagarajan. London: Academic Press. 2018.
12. The human skin microbiome by A.L. Byrd, Y. Belkaid, and J.A. Segre. *Nature reviews in Microbiology*, *16*(3), 143–155. https://doi.org/10.1038/nrmicro.2017.157. 2018.
13. Insights into the human oral microbiome by D. Verma, P.K. Garg and A.K. Dubey. *Archives of microbiology*, *200* (4), 525–540. https://doi.org/10.1007/s00203-018-1505-3. 2018.
14. Human Gut Microbiome: Function Matters by A. Heintz-Buschart and P. Wilmes. *Trends in microbiology*, *26*(7), 563–574. https://doi.org/10.1016/j.tim.2017.11.002. 2018.
15. *Functional Metagenomics: Tools and Applications* by T. Charles, M. Liles, A. Sessitsch, Springer. 2017.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE – 16:
MICROBIAL DIAGNOSIS AND PUBLIC HEALTH MANAGEMENT

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSE 16: MICROBIAL DIAGNOSIS AND PUBLIC HEALTH MANAGEMENT	**4**	**2**	**0**	**2**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to introduce the students to diagnostic microbiology and public health management. Students will be exposed to various methods of sampling of specimens for laboratory diagnosis.
- Student will be introduced to various automated systems and methods of pathogen identification and microbial typing. Students will develop an understanding of basic concepts of epidemiology. They will be introduced to the role of environment in human health and key aspects of disaster management.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to explain the methods of collection and transport of clinical specimens, the automated systems for pathogen identification and various methods of microbial typing.
- Student will be able to describe epidemiology, types of epidemics and pandemics, the epidemiology of infectious diseases, the reservoirs of infectious agents and modes of transmission of various diseases.

- Student will be able to explain the concept of one health, various types of zoonoses, overview of air and water pollution and its impact on human health, the key aspects of disaster management.
- Student will be able to describe the significance of various parameters determining health, the methods of blood sampling used for various animals, and demonstrate rapid diagnostic techniques.
- Student will be able to analyze epidemiological data to calculate mortality and morbidity rates, explain about epidemics through case studies.
- Student will be able to describe various disease control regulatory agencies (National and International), genome and disease surveillance.

Contents:

Theory: **30 hours**

Unit 1: (10 hours)

General principles of diagnosis and microbial typing methods: Challenges of diagnosis. General principles of specimen collection. Choice of clinical samples and methods of collection. Transportation of clinical samples. Evaluation of a diagnostic test based on specificity, sensitivity, positive predictive value, negative predictive value. Automated systems of pathogen identification: a brief outline of BACTEC, MALDI-TOF, VITEK, and their advantages and disadvantages. Microbial typing: phage typing, bacteriocin typing, serotyping, antibiogram typing, plasmid profile analysis.

Unit 2: (12 hours)

Basic concepts of epidemiology: Definitions: health, epidemiology, prevalence, birth rate, morbidity, mortality, sero-prevalence, genome surveillance, R^o value, quarantine, endemic, epidemics and types (common source, propagated/progressive, mixed), pandemic, travel notice, public health guidelines. Uses of epidemiology. Infectious disease epidemiology. Modes of transmission of disease and its dynamics, human reservoirs, animal reservoirs, carriers. Investigation of an epidemic. Role of immunization in public health. Clinical trials: randomized control trials (multiple treatment arms, factorial design, cluster design), nonrandomized trials.

Unit 3: (8 hours)

Environment and Health: The concept of one health. Definition, history and socio-economic impact of zoonotic diseases. Classification of zoonoses with examples (based on transmission cycle: orthozoonoses, cyclozoonoses, metazoonoses, saprozoonoses;

based on reservoir hosts: anthrapozoonoses, zooanthroponoses, amphixenoses). Air pollution and its effects. Water pollution and its effect. Disaster management: key aspects.

Practicals: **60 hours**

Unit 1: (30 hours)

Health indicators, blood sampling methods and diagnostic methods: Student individual project: preparation of a short report on indicators of health. Guidelines and collection sites for sampling of blood from humans, cattle, sheep and goat. **Student group study project:** preparation of a flow chart for detection of microbial pathogens for two diseases prevalent in India. Principles and working of rapid antibody detection test using COVID-19 as example. Principles and working of antigen and antibody detection kits for HIV. Principle and working of slide agglutination test for typhoid. Principles and working of quantitative real time PCR test for COVID-19 through virtual lab.

Unit 2: (15 hours)

Epidemiological Data Analysis: Student group research study: Case studies of a common source epidemic (Cholera outbreak, London, 1854) and progressive epidemic (SARS 2002, MERS 2012, and COVID-19). **Student group research project**: Measurement of disease: determination of morbidity and mortality rates/ratios. Generation of epidemiological protocols and reports.

Unit 3: (15 hours)

Case Studies through student group research projects: INSACOG: role in SARS- CoV-2 genome surveillance, Role of WHO and National Centre for Disease Control in disease management, AMR stewardship and National Action Plan, CDC –EOC levels (www.cdc.gov).

Suggested Reading (Theory & Practical):

1. Park's Textbook of Preventive and Social Medicine by K. Park. 26th edition. Banarsidas Bhanot Publishers, India. 2021.

2. Brock Biology of Microorganisms by M.T. Madigan, K.S. Bender, D.H. Buckley, W.M.Sattley and D.A. Stahl. 16th edition. Pearson Education, USA. 2021.

3. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition.

Pearson Education, USA. 2020.

4. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGrawHill Higher Education, USA. 2019.
5. National Centre for Disease Control: Anti-Microbial Resistance and COVID National Action plan: https://ncdc.gov.in/index1.php?lang=1&level=2&sublinkid=389&lid=347
6. Microbiology: An Introduction by G.J. Tortora, B.R. Funke,and C.L. Case. 13th edition. Pearson, USA. 2018.
7. Textbook of Microbiology by R. Ananthanarayan and C.K.J. Paniker. 10th edition.Universities Press, India. 2017.
8. Veterinary Microbiology by D. Scott McVey, Melissa Kennedy and M.M. Chengappa. 3rd edition. Wiley – Blackwell, USA. 2013.
9. An Introduction to Public Health and Epidemiology by S. Carr, N. Unwin and T. Pless-Mulloli. 2nd edition. Open University Press, UK. 2007.
10. Handbook of Good Dairy Husbandry Practices. National Dairy Development Board (NDDB). https://www.nddb.coop/sites/default/files/handbook_of_good_dairy_husbandry_practices_low.pdf
11. Mackie and McCartney Practical Medical Microbiology by J. Collee, A. Fraser, B. Marmion and A. Simmons. 14th edition. Elsevier. 1996.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DEPARTMENT OF MICROBIOLOGY
SEMESTER-IV
B.Sc. (Hons.) Microbiology

DISCIPLINE SPECIFIC CORE COURSE – 10: ADVANCES IN CELL BIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSC401: ADVANCES IN CELL BIOLOGY	4	3	0	1	Class XII pass with Biology/ Biotechnology/ Biochemistry	Basic Concepts of Cell Biology

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to introduce the students to the essentials of eukaryotic cell biology.
- The students will gain knowledge about the physical and chemical architecture of cells as well as structural and functional details of different cell organelles.
- They will become familiar with cell cycle events, and mechanisms of cell communication and cell death.
- They will be educated about the hallmarks, etiology and diagnosis of cancers.
- They will be introduced to the cutting edge science of stem cell technology, their production and various applications.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to describe the different components of cell signalling pathways used for cell communication.
- Student will be able to recall cell division, mechanisms of cell cycle regulation, and types of cell death.
- Student will be able to evaluate the importance of stem cells and their associated technologies and applications.

- Student will be able to describe the different types of cancers, their causes, characteristics, diagnosis, and treatment modalities.
- Student will be able to analyze DNA by Feulgen staining followed by microscopic observation. Student will be able to analyze the different stages of cell division: mitotic stages by temporary mount and meiosis stages by the permanent mount.
- Student will be able to evaluate chromosome polyploidy by colchicine treatment of plant material followed by staining.

SYLLABUS OF DSC-10

UNIT – I (20 hours)

Cell Signalling: Modes of cell-cell signalling: endocrine, paracrine, autocrine. Signalling molecules: nitric oxide, carbon monoxide, steroid hormones, neurotransmitters, peptide hormones and growth factors. Cell surface receptors and receptor-ligand interactions: G protein-coupled receptors, receptor protein tyrosine kinases, cytokine receptors. Signal transduction: cyclic AMP, cyclic GMP and MAP kinase pathways.

UNIT – II (10 hours)

Cell Cycle and Cell Death: Phases and regulation of eukaryotic cell cycle. Mitosis and meiosis. Types of cell death: necrosis, apoptosis and autophagy, mitophagy. Characteristics and pathways of apoptosis: intrinsic and extrinsic.

UNIT – III (5 hours)

Cell Renewal: Stem cells: characteristics and types: somatic stem cells, embryonic stem cells, induced pluripotent stem cells. Therapeutic applications of stem cells.

UNIT – IV (10 hours)

Cancer biology: Hallmarks of cancer. Causes of cancer: carcinogens, cancer-causing microorganisms. Proto-oncogenes and oncogenes. Tumor suppressor genes. Characteristic features of cancer cells. Types of cancers. Cancer stem cells. Approaches to cancer diagnosis. Currently available cancer treatment modalities (including bone marrow transplantation, immune cell and oncolytic viral therapies).

Practical component

UNIT 1: (20 hours)

Cell division and cytochemical analysis of DNA: Performance of cytochemical staining of DNA by Feulgen stain. Microscopic examination and analysis of the different stages of mitosis through temporary mounts of stained onion root tip. Microscopic examination and analysis of the different stages of meiosis through temporary mounts / permanent slides.

Unit 2: (10 hours)

Chromosome polyploidy and properties of cancer cells: Study of polyploidy in onion root tip by colchicine treatment followed by acetocarmine stain. Identification and

study of properties of different types of cancerous cells through light and electron micrographs.

Essential/recommended readings

Theory:

1. Molecular Cell Biology by H. Lodish, A. Berk, C. Kaiser, M. Krieger, A. Bretscher, H.Ploegh, A. Amon and K.C. Martin. 9th edition. W.H. Freeman, UK. 2021.
2. Essential Cell Biology by B. Alberts, K. Hopkin, A.D. Johnson, D. Morgan, and M. Raff. 5th edition. W.W. Norton & Co, USA. 2019.
3. Karp's Cell and Molecular Biology by G. Karp, J. Iwasa and W. Marshall. 9th edition. Wiley, USA. 2019.
4. The Cell: A Molecular Approach by G.M. Cooper. 8th edition. Sinauer Associates, UK. 2018.
5. The science of stem cells by J.M.W. Slack. 1st edition. John Wiley & Sons. 2018.
6. Cell Biology by T.D. Pollard, W.C. Earnshaw, J. Lippincott-Schwartz and G.T. Johnson. 3rd edition. Elsevier, USA. 2016.
7. Becker's World of the Cell by J. Hardin and G. Bertoni. 9th Edition. Pearson, USA. 2015.
8. Principles of stem cell biology and cancer: future applications and therapeutics by T. Regad, T. Sayers and R. Rees. 1st edition. John Wiley & Sons. 2015.
9. Essentials of stem cell biology edited by R. Lanza and A. Atala. 3rd edition. Academic Press. 2013.
10. Cell and Molecular Biology by E.D.P. De Robertis. 8th edition. Lippincott, Williams andWilkins, USA. 2006.

Practicals:

1. A Cell Biology Manual by J. Francis. Kendall/Hunt Publishing Co, USA. 2022.
2. Practical Laboratory Manual- Cell Biology by A. Gupta, B.K. Sati. Lambert Academic Publishing, USA. 2019.
3. Cell Biology Practical Manual by R. Gupta, S. Makhija and R. Toteja. Prestige Publishers, India. 2018.
4. Laboratory Manual of Cell Biology by R. Majumdar, R. Sisodia. Prestige Publishers, India. 2018.
5. Essential Cell Biology Vol 1: Cell Structure- A Practical Approach by J. Davey and M.Lord. Oxford University Press, UK. 2003.
6. Essential Cell Biology Vol 2: Cell Function- A Practical Approach by J. Davey and M. Lord. Oxford University Press, UK. 2003.

Suggestive readings

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE –11:
MICROBIAL PHYSIOLOGY AND METABOLISM- II

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSC402: **MICROBIAL PHYSIOLOGY AND METABOLISM-II**	**4**	**3**	**0**	**1**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**Microbial Physiology and Metabolism-I**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to enable students to understand the underlying mechanisms governing various physiological and metabolic features of prokaryotes.
- These include transport mechanisms for the uptake of nutrients, bacterial growth, and the diversity of prokaryotes due to (i) adaptations to the different habitats in which they grow and (ii) metabolic pathways for energy production and carbon and nitrogen assimilation.
- The course will build the strong foundation needed by the students for further studies in the advanced fields of microbiology including metabolic engineering.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to elaborate on various pathways of fermentation in microbes.
- Student will be able to discuss the classification of chemolithotrophs and phototrophs along with mechanisms of energy production and cellular carbon synthesis.
- Student will be able to describe the nitrogen cycle and its assimilation and dissimilation by processes like nitrogen fixation, ammonia assimilation, nitrification, denitrification etc.

- Student will be able to evaluate the diversity of metabolic pathways in microbes by designing and formulation of microbial culture media and studying the effect of changing chemical environment on fungal growth using various carbon sources.
- Student will be able to evaluate the diversity of metabolic pathways in microbes by studying the effect of changing chemical environment on bacterial growth using various nitrogen sources.

SYLLABUS OF DSC-11

UNIT – I (8 hours)

Microbial fermentations: Principles of fermentation. Alcohol fermentation and Pasteur effect. Lactate fermentation (homofermentative and heterofermentative pathways). Concept of linear and branched fermentation pathways.

UNIT – II (12 hours)

Metabolism in chemolithotrophic autotrophs: Physiological groups of chemolithotrophs (aerobic and anaerobic). Detailed mechanism of energy production and generation of reducing power in H2 oxidizers and methanogens.

UNIT – III (13 hours)

Metabolism in phototrophic autotrophs: Families of phototrophic bacteria, bacterial photosynthetic pigments, generation of energy and reducing power in purple and green bacteria (anoxygenic photosynthesis) and cyanobacteria (oxygenic photosynthesis), photophosphorylation (cyclic and non- cyclic). Production of cellular carbon (C1 metabolism) in autotrophs by Calvin cycle & reductive TCA pathway and by acetyl-CoA in methanogens.

UNIT – IV (12 hours)

Nitrogen Metabolism: Biological nitrogen fixation: Diversity, mechanism of nitrogen fixation, nitrogenase activity and its physiological regulation, alternate nitrogenases, ammonia assimilation, assimilatory nitrate reduction. dissimilatory nitrate reduction (denitrification, nitrate/ nitrite and nitrate/ ammonia respiration).

Practical component

UNIT 1: (15 hours)

Carbon metabolism: Comparison of the growth of A. niger in minimal medium containing different carbon sources (glucose, fructose and lactose) on different days of growth using dry weight method.

Unit 2: (15 hours)

Nitrogen metabolism: Study of the effect of nitrogen sources (ammonium, nitrate and peptone) on the growth of E. coli. Investigation any one bacterium for its nitrifying / denitrifying properties

Essential/recommended readings

Theory:

1. Fundamentals of Bacterial Physiology and Metabolism by Rani Gupta and Namita Gupta. Springer Nature Singapore Pvt. Ltd., Singapore. 2021.
2. Lehninger Principles of Biochemistry by D.L. Nelson and M.M. Cox. 8th edition. W.H. Freeman and Company, UK. 2021.
3. Brock Biology of Microorganisms by M.T. Madigan,J. Aiyer,D. Buckley,W.Sattley and D. Stahl.16th edition. Pearson, USA. 2021.
4. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGrawHill Higher Education, USA. 2019.
5. Microbial Biochemistry by G.N. Cohen. 2nd edition. Springer, Germany. 2014.
6. The Physiology and Biochemistry of Prokaryotes by D. White, J. Drummond and C. Fuqua. 4th edition. Oxford University Press, UK. 2011.
7. Microbial Physiology by S.R. Reddy and S.M. Reddy. Scientific Publishers India. 2007.
8. Microbial Physiology by A.G. Moat, J.W. Foster and M.P. Spector. 4th edition. John Wiley& Sons, USA. 2002.

Practicals:

1. Essentials of Practical Microbiology by A. Sastry and S. Bhat. 2nd edition. Jaypee Brothers Medical Publishers, India. 2021.
2. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition. Pearson Education, USA. 2020.
3. Laboratory Experiments in Microbiology by T. Johnson and C. Case. 12th Edition. Pearson Education, USA. 2019.
4. Microbiology Practical Manual edited by A. Jain, J. Agarwal, V. Venkatesh. Elsevier, India. 2018.
5. Applied Microbial Physiology: A Practical Approach by P. M. Rhodes and P. F. Stanbury. IRC Press. 1997.

Suggestive readings

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 12:
VIROLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSC403: **VIROLOGY**	**4**	**3**	**0**	**1**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to make students aware of the extent to which the tiniest of microorganism (viruses) leave their impact on human and animal health as well as in agriculture.
- Students will get acquainted with the structures and replication strategies of bacterial, plant and human viruses.
- Students will gain in-depth knowledge of how viruses infect their host, spread across a population, and cause diseases.
- They will learn of preventive measures used for protection against viral infections, and control
- They will acquire knowledge of emerging and re- emerging viruses in context to public health threats taking coronavirus as the case study.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to describe the nature, properties and structure of viruses, and be knowledgeable about sub-viral particles, giant viruses and viral taxonomy.
- Student will be able to discuss bacterial viruses, their salient features, and replication strategy of important bacteriophages.
- Elaborate on plant viruses, modes of transmission and their economic importance.
- Student will be able to evaluate the salient features and replication strategies of important human viruses, and will have understood the concept of oncogenesis, DNA and RNA cancer-causing viruses.
- Student will be able to describe how to prevent viral infections using vaccines and antiviral compounds.

- Student will be able to assess the problems of emerging and re-emerging viruses, having an understanding of the rise of coronavirus as the major public health crisis along with the implemented management protocols.

SYLLABUS OF DSC-12

UNIT – I (9 hours)

Introduction to Virology: History of virology. Nature and general properties of viruses, concept of viroids, virusoids, satellite viruses, prions, giant viruses (mama, mimi and pandora virus), virophages (Sputnik). Structure of viruses: Capsid symmetry, enveloped and non- enveloped viruses. Isolation, purification and cultivation of viruses. Viral taxonomy: Classification and nomenclature of different groups of viruses.

UNIT – II (8 hours)

Bacteriophages: Diversity, one step multiplication curve. T4 phage: Unusual bases, terminal redundancy, lytic cycle, assembly, maturation and release of progeny virions. Lambda phage: genome structure, concept of early and late proteins, lytic cycle and lysogeny. øX174 phage: Overlapping genes, and rolling circle replication.

UNIT – III (3 hours)

Plant Viruses: Diversity, modes of transmission (non-persistent, semi persistent and persistent), salient features of replication of Geminivirus. Economic importance of plant viruses : adverse and beneficial effects. Virus-like particles (VLPs) and their applications in medicine.

UNIT – IV (18 hours)

Human Viruses: Diversity, routes of transmission: vertical and horizontal (vector-borne, air-borne, oral-faecal borne) infection cycle. Replication of Human Immuno Deficiency Virus (HIV) and Polio Virus. Overlapping genes. Partial double stranded genomes: Hepatitis B. Segmented genomes: Influenza virus. Non-segmented genomes: Picornavirus. Assembly with example of Polio virus. Oncogenic viruses: types of oncogenic DNA and RNA viruses. Emerging and Re-emerging viruses: H1N1, Dengue, Ebola, Zika virus and associated pandemics and epidemics. Case study of the SARS-CoV2 Corona virus as the recent public health threat: emergence, epidemiology, management protocols, emergence of variants, global impact

UNIT – V (7 hours)

Prevention and Control of Viral Diseases: Antiviral compounds and their mode of action: AZT, ritonavir, lamivudine. Interferons and their mode of action. General principles of viral vaccines: live attenuated vaccines, inactivated viral vaccine, subunit vaccine, recombinant viral vaccine.

Practical component

UNIT 1: (22 hours)

Structure and isolation of viruses: Principle and use of electron microscopy to study virus structure. Use of electron micrographs for studying the structural characteristics of the following viruses: Bacterial viruses: ϕX174, T4, λ. Plant viruses: caulimo, gemini, tobacco ringspot, cucumber mosaic and alfalfa mosaic viruses. Human viruses: rhabdo, influenza, paramyxo, hepatitis B and retroviruses.

Isolation of bacterial and plant viruses: Isolation and enumeration of bacteriophages (PFU) from water/sewage samples using double agar layer technique. Qualitative analysis of lytic and lysogenic phage by observation of plaque phenotypes (clear versus turbid). Isolation of plant viruses from infected leaves followed by locally inoculating healthy plant leaves to confirm isolation and infectivity. Use of the local lesion assay to observe characteristic lesions formed on the plant leaves and measure of infectivity of the virus by enumeration of the number of local lesions on the inoculated leaves.

Unit 2: (8 hours)

Isolation and propagation of animal viruses: Principle and working method of using chick embryo cultivation technique. Demonstration of the method using videos. Cytopathic effects of viruses: observation of the physical attributes of virus-infected cells of different types with suitable photographs and images.

Essential/recommended readings

Theory:

1. Fields Virology: DNA Viruses (Vol 2) by P.M. Howley, D.M. Knipe, J.L. Cohen, B.A. Damania. 7th edition. Walters Kluwer, Netherlands. 2021.
2. Fields Virology: Emerging Viruses (Vol 1) by P.M. Howley, D.M. Knipe, S. Whelan. 7th edition. Walters Kluwer, Netherlands. 2020.
3. Principles of Virology, Molecular biology, Pathogenesis and Control by S. Flint, L. Enquist, R. Krug, V. Racaniello, A. Skalka. 5th edition. ASM press, USA. 2020.
4. Plant Viruses: Diversity, Interaction and Management by R.K. Gaur, S.M.P. Khurana, and Y. Dorokhov. CRC Press. Taylor & Francis Group. 2018.
5. Principles of Molecular Virology by A.J. Cann. 6th edition. Academic Press, Elsevier Netherlands. 2016.
6. Introduction to Modern Virology by N.J. Dimmock, A.L. Easton and K.N. Leppard. 7th edition.Wiley-Blackwell Publishing. 2016.
7. Understanding Viruses by Teri Shors Jones. 3rd edition. Jones and Bartlett Learning, USA. 2016.
8. Plant Virology by R. Hull. 5th edition. Academic Press, USA. 2014.
9. Virology: Principles and Applications by J. Carter and V. Saunders. 2nd edition. John Wiley andSons, UK. 2013.
10. Plant Viruses by M.V. Nayudu. Tata McGraw Hill, India. 2008.
11. Basic Virology by E.K. Wagner, M.J. Hewlett, D.C. Bloom. 3rd edition. Wiley-Blackwell Publishing. 2007.
12. Virology by J.A. Levy, H.F. Conrat and R.A. Owens. 3rd edition. Prentice Hall, USA. 2000.

Practicals:

1. Benson's Microbiological Applications, Laboratory Manual in General Microbiology by A. Brown and H. Smith. 15th edition. McGraw-Hill Education, USA. 2022.
2. Bacteriophages by D., Harper, S., Abedon, B., Burrowes, and M. McConville. 1st edition. Springer, Switzerland. 2021.
3. Freshney's Culture of Animal Cells by R. I., Freshney and A. Capes-Davis. John Wiley and Sons. U.K. 2021.
4. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition. Pearson Education, USA. 2020.
5. Manual of Clinical Microbiology, 2 Volume set by K. C., Carroll, M. A., Pfaller, M. L., Landry, A. J., McAdam, R., Patel, S. S., Richter and D. W. Warnock. 12th edition. ASM Press. USA. 2019.
6. Experiments in Microbiology, Plant Pathology and Biotechnology by K. R. Aneja. 5th edition. New Age International Publishers, India. 2017.
7. Practical Plant Virology by J., Dijkstra and C., Jager. Springer Science and Business Media. Germany. 2012.
8. A Colour Atlas of Virology by J. Versteeg. Mosby International. Taiwan. 1990.

Suggestive readings

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SEMESTER-V
B.Sc. (Hons.) Microbiology

DISCIPLINE SPECIFIC CORE COURSE – 13: PRINCIPLES OF MOLECULAR BIOLOGY-I

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSC501: **PRINCIPLES OF MOLECULAR BIOLOGY-I**	**4**	**3**	**0**	**1**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is for the student to gain comprehensive knowledge of the basic concepts of molecular biology.
- The student will become familiar with DNA-related cellular processes and will become aware of the central dogma of molecular biology, learning about the propagation of information through DNA replication and the unidirectional flow of information from DNA to RNA to proteins through transcription and translation

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to describe DNA and RNA as genetic material and the structure and properties of the different DNA types as well as the various kinds of RNA.
- Student will be able to explain the process of propagation of information in prokaryotes and eukaryotes by DNA replication and the various enzymes and other proteins that modulate this process.
- Student will be able to describe the basic prokaryotic and eukaryotic transcription processes, including the RNA polymerases and general transcription factors involved, differentiate between the processes in prokaryotes and eukaryotes.
- Student will be able to evaluate the relevance of the double helical structure of DNA in the propagation of genetic material.
- Student will be able to demonstrate the isolation of genomic DNA and plasmid from bacterial cells, and analyze them through agarose gel electrophoresis.

SYLLABUS OF DSC-13

UNIT – I (12 hours)

Structure and properties of nucleic acids: Types of genetic material: DNA and RNA. Structure of DNA: characteristic features of double helix. Properties of different types of DNA: A, B and Z. Denaturation and renaturation of DNA, factors affecting renaturation kinetics, concept of Tm. Principle and method of cot curve analysis of DNA. Factors affecting DNA topology: role of topoisomerases I and II. Concept of linking number. Concept of concatenation and concatamerization. DNA organization in prokaryotes and eukaryotes. Structure and function of RNA: rRNA, tRNA and mRNA.

UNIT – II (17 hours)

Replication of DNA in prokaryotes and eukaryotes: Semi-conservative DNA replication. Unidirectional and bidirectional DNA replication. DNA replication modes with one example each: D-loop (mitochondrial), Θ (theta), rolling circle. Structure of origins of replication in prokaryotes versus eukaryotes, initiators and replicators. Mechanism of origin activation in prokaryotes (E.coli) and eukaryotes (S.cerevisiae). Mechanism of DNA replication: semi-discontinuous replication, leading and lagging strand synthesis. Replication machinery in prokaryotes and eukaryotes: primase, DNA polymerases, DNA ligase. Mechanisms for maintaining fidelity of replication. Differences in prokaryotic and eukaryotic DNA replication. Regulation of replication in prokaryotes and eukaryotes. Replication of chromosome ends: mechanism of action of telomerase, importance of telomerase in ageing.

UNIT – III (16 hours)

Transcription in prokaryotes and eukaryotes: Distinction between replication and transcription. Concept of transcription unit. Concept of operon and polycistronic transcription in prokaryotes. RNA polymerases in prokaryotes and eukaryotes. Structure and properties of promoter in prokaryotes and eukaryotes. Role of enhancers and silencers in gene regulation. General transcription factors in eukaryotes. Process of transcription initiation and elongation in prokaryotes and eukaryotes. Transcription termination: rho-dependent and rho-independent termination mechanisms. Inhibitors of transcription and their mechanism. Comparison of the transcription process in prokaryotes versus in eukaryotes

Practical component

UNIT 1: (12 hours)

Study of different types of DNA and RNA:

Student research study project: Discovery of DNA as genetic material. Discovery of structure of DNA: the double helix.

Study of the structure and properties of different types of DNA using micrographs and/or models: A-DNA, B-DNA and Z-DNA. Study of the structure and properties of various RNAs using micrographs: mRNA, rRNA, tRNA, miRNA, siRNA, guide RNA, xistRNA, snRNA, snoRNA. Discussion on the importance of the double helix

structure in DNA replication by semi- conservative mode: the Meselson & Stahl experiment.

Unit 2: (18 hours)

Isolation and analysis of DNA:

Isolation of genomic DNA from Escherichia coli cultures: cell lysis and DNA precipitation. Analysis of the isolated genomic DNA: principle and working method of agarose gel electrophoresis. Isolation of plasmid DNA using alkaline lysis method. Analysis of the isolated plasmid DNA by agarose gel electrophoresis. Identification of the different forms of plasmid DNA by agarose gel electrophoresis.

DNA estimation: colorimetric estimation of DNA using salmon sperm DNA or calf thymus DNA as standard: diphenylamine method. Spectrophotometric method using absorbance at 260 nm.

Essential/recommended readings

Theory:

1. Lewin's Essential Genes by J. Krebs, E. Goldstein and S. Kilpatrick. 4th edition. Jones andBartlett Publishers, USA. 2020.
2. Karp's Cell and Molecular Biology by G. Karp, J. Iwasa and W. Marshall. 9th edition. Wiley, USA. 2019
3. Molecular Biology by D. Clark, N. Pazdernik and M. McGehee. 3rd edition. Academic Cell, USA. 2018.
4. Lewin's Genes XII by J. Krebs, E. Goldstein and S. Kilpatrick. 12th edition. Jones and BartlettLearning, USA. 2017.
5. Becker's World of the Cell by J .Hardin and G.P. Bertoni. 9th edition. Pearson, USA. 2015.
6. Principles of Genetics by D.P. Snustad and M.J. Simmons. 7th edition. Wiley and Sons, UK. 2015.
7. Molecular Biology of the Gene by J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levine and R. Losick. 7th edition. Pearson Education, USA. 2014.
8. Cell and Molecular Biology by E.D.P. De Robertis and E.M.F. De Robertis. 8th edition. Lippincott Williams and Wilkins, USA. 2006.

Practicals:

1. Molecular Cloning: A Laboratory Manual by M. Green and J. Sambrook Volumes 1-3. 4th edition. Cold Spring Harbor Laboratory Press, USA. 2012.
2. An Introduction to Practical Biochemistry by D. Plummer. 3rd edition. McGraw Hill Education, India. 2017.

Suggestive readings

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 14:
BASIC CONCEPTS OF IMMUNOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSC502: **BASIC CONCEPTS OF IMMUNOLOGY**	**4**	**3**	**0**	**1**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**None**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to give the students insight into how the human body tackles diseases and what mechanisms of defense are used in protection processes.
- The students will develop a clear understanding of the various components of the immune system and will become aware of the characteristics of antigens, their types and various antibodies produced by the system to defend us from the invading microorganisms.
- The student also learns about the major histocompatibility complex, the complement system, monoclonal antibodies and cytokines, which are of paramount importance in triggering an efficient immune response.

Learning outcomes

The Learning Outcomes of this course are as follows:

- The student will be able to describe various types of immune responses and the basic processes involved therein, how the immune system protects us from infection using various lines of defense.
- The student will be able to explain the characteristics and functions of the cells of the immune system as well as the structure and functioning of various organs of the immune system, and immunodiagnostic techniques.
- The student will be able to explain the important properties of antigens as well as how environmental factors affect antigen immunogenicity; the structure, types, and functions of antibodies, monoclonal and chimeric antibodies.

- The student will be able to describe the major histocompatibility complex proteins and their loci in the genome along with the two distinct pathways for processing and presentation of exogenous and endogenous antigens.
- The student will be able to discuss the mechanisms by which the complement system is activated via three distinct pathways so as to support the antibodies and phagocytes to clear microbes and damaged cells with utmost efficacy.

SYLLABUS OF DSC-14

UNIT – I (10 hours)

Basic Introduction to immune system: Components of innate immunity: Anatomical and physiological barriers, chemical mediators, non-specific defence mechanisms, inflammatory response, phagocytosis, Pattern Recognition Receptors (PRR). Features of Adaptive Immunity, Cytokines and cytokine receptor families with emphasis on IL-2R.

UNIT – II (10 hours)

Cells and organs of Immune System: Hematopoiesis, structures, functions and properties of cells of lymphoid lineage (T cell, B cell, NK cell) and myeloid lineage (macrophage, neutrophil, eosinophil, basophil, mast cell, dendritic cell). Separation of cells using Flow Cytometry. Primary and secondary immune organs (bone marrow, thymus, spleen, lymph nodes, GALT).

UNIT – III (15 hours)

Antigens and antibodies: Properties of Antigens: foreignness, molecular size, heterogeneity. Antigenicity and immunogenicity, environmental factors affecting immunogenicity of an antigen, adjuvants, epitopes of an antigen (T and B cell epitopes), T-dependent and T-independent antigens, haptens.

Elucidation of antibody structure; types, functions and properties of antibodies, antigenic determinants on antibodies (isotypic, allotypic, idiotypic), monoclonal and chimeric antibodies, immunoglobulin superfamily. Immunodiagnostics by SDS-PAGE, western blotting, ELISA and its types, immunofluorescence, immunoelectron microscopy.

UNIT – IV (5 hours)

T Cell Receptor, Major Histocompatibility Complex and Antigen Presentation: Structure and functions of TCR-CD3 complex, MHC I & MHC II molecules, organization of MHC locus (mouse and human), antigen processing pathways (cytosolic and endocytic).

UNIT – V (5 hours)

Complement and Activation Pathways: Components of complement system, Complement activation pathways (classical, alternative and lectin) and their biological consequences.

Practical component

UNIT 1: (18 hours)

Introduction to Immunology:

Student study research project: The contributions of the following scientists to the development of the field of immunology: Edward Jenner, Paul Ehrlich, Peter Medawar, MacFarlane Burnet, Neils K Jerne, Susumu Tonegawa, Jules Bordet, Peter C. Doherty & Rolf M. Zinkernagel, Cesar Milstein & Georges E. Kohler, and George Snell, Jean Dausset & Baruj Benacerraf.

Cells of Immune system:

Familiarizing students with the haemocytometer and its uses. Determining total leucocyte count in the given blood sample: making a smear of human blood and performing total and differential leukocyte count, determining percent count neutrophils, lymphocytes, eosinophils, basophils and monocytes. Study of the association of abnormal blood counts with diseases like leukopenia, leukocytosis, neutropenia.

Unit 2: (12 hours)

Basic Immunodiagnostic techniques:

Concepts of agglutination and identification of human blood groups. Understanding the concepts of immunoprecipitation by performing double immunodiffusion (Ouchterlony method). Principles, working methods and applications of Lateral Flow Test and Plate/ Dot ELISA. Performance of Plate/ Dot ELISA, and Lateral Flow Test using any diagnostic kit.

Essential/recommended readings

Theory:

1. Immunology: A short course by R. Coico. 8th edition. Wiley- BlackwellScientific Publication, UK. 2021
2. Cellular and Molecular Immunology by A.K. Abbas, A.H. Lichtman and S. Pillai. 10th edition.Elsevier, USA. 2021.
3. Kuby Immunology by J. Punt, S. Stranford, P. Jones and J. Owen. 8 th edition.
4. W.H. Freemanand Company, USA. 2018.
5. Roitt's Essential Immunology by P. Delves, S. Martin, D. Burton and I.M. Roitt. 13th edition.Wiley- Blackwell Scientific Publication, UK. 2017.
6. Janeway's Immunobiology by K. Murphy and C. Weaver. 9th edition. Garland Science Publishers, USA. 2016.
7. Basic and Clinical Immunology by M. Peakman and D. Vergani. 2nd edition. ChurchillLivingstone, UK. 2009.
8. Immunology by C. Richard and S. Geoffrey. 6th edition. Wiley- Blackwell Scientific Publication, UK. 2009.

Practicals:

1. A Handbook of Practical and Clinical Immunology Volumes I & 2 by G. P. Talwar and S.K. Gupta. 2nd edition. CBS Publishers, India. 2017.
2. Practical Immunology, A Laboratory Manual by S. Balakrishnan, K. Karthik and S. Duraisamy. Lambert Academic Publishing, India. 2017.

3. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 11th edition. Pearson Education, USA. 2016.
4. Laboratory Manual on Immunology and Molecular Biology by D. Dwivedi and V. Singh. Lambert Academic Publishing, India. 2013.
5. Practical Immunology by F.C. Hay, M.R. Olwyn and M.R. Westwood. 4th edition. Wiley Blackwell Publishing. 2002.

Suggestive readings

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE –15: MEDICAL MICROBIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSC503: MEDICAL MICROBIOLOGY	4	3	0	1	Class XII pass with Biology/ Biotechnology/ Biochemistry	None

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to introduce the students to the fundamental features of medical microbiology.
- Students will recognize the diversity of microbial pathogens and their virulence mechanisms. They will be introduced to specific infectious diseases of global relevance, diagnostic methods, and methods to manage infectious diseases.
- They will become familiar with the functional aspects of antimicrobial chemotherapy and anti- microbial resistance and will gain insights into the recent development of new molecular diagnostic methods as well as the global spread and emergence of infectious agents.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to explain the terms in describing disease causalities, pathogenic features of microbial agents of disease, and their transmission, and will be able to describe the diverse nature of the human microbiome and its significance.
- Student will be able to describe the spectrum of diseases caused by bacterial pathogens, and the course of disease development and accompanying symptoms. Student will be able to to discuss the methods of transmission, epidemiological aspects, preventive measures, treatments.
- Student will be able to explain the human diseases caused by viruses including emerging viral pathogens, giving an understanding of the etiology, course of disease development, symptoms, diagnosis and management of these diseases.
- Student will be able to elaborate on the fungal and protozoan diseases with respect to their etiology, symptoms, transmission, diagnosis and control.
- Student will be able to explain the basic concepts of handling clinical specimens, and approaches used to aid in detection/ diagnosis of infectious agents using immunological and molecular biology-based methods.
- Student will be able to evaluate the mode of action of different antimicrobial agents, concept of antimicrobial resistance and immunization schedule followed in India.

SYLLABUS OF DSC-15

UNIT – I (7 hours)

Introduction to pathogenicity, infection and human microbiota: Commonly used terms and nomenclature: pathogen, infection, invasion, virulence and its determinants, endotoxins and exotoxins, carriers and their types. Opportunistic, nosocomial, acute, latent and chronic infections. Sepsis and septic shock. Modes of transmission of pathogens. Role of microbiome in human health. Factors governing the microbiota of skin, throat and upper respiratory tract, gastrointestinal tract, urogenital tract (with examples of microorganisms in each instance).

UNIT – II (12 hours)

Bacterial pathogens causing common diseases in humans: Symptoms, transmission, prophylaxis and treatment of the diseases caused by: Bacillus anthracis, Clostridium tetani, Clostridium difficile, Escherichia coli, Helicobacter pylori, Mycobacterium tuberculosis, Staphylococcus aureus, Salmonella enterica Typhi, Treponema pallidum, Vibrio cholerae

Unit III: (12 hours)

Viral diseases in humans: Etiology, symptoms, transmission, diagnosis, prophylaxis, and treatment of the following diseases: Polio, Chicken pox, Mumps, Measles, Herpes, Hepatitis, Rabies, AIDS, Influenza (swine flu and bird flu), Dengue, Japanese Encephalitis, Rota virus infections, COVID-19.

UNIT – IV (4 hours)

Protozoan and fungal diseases in humans: Etiology, symptoms, transmission, diagnosis and control of Malaria and Kala azar. Types of mycoses. Detailed study of certain mycoses. Cutaneous mycoses: Tinea pedis (Athlete's foot). Systemic mycoses: Aspergillosis. Opportunistic mycoses: Candidiasis, Mucormycosis.

UNIT – V (10 hours)

Diagnostics and therapeutics in infectious diseases:

Collection, transport and culturing of clinical samples. Principles of different diagnostic tests: Agglutination-based tests (Widal and VDRL test), lateral flow assay-based kits, immunofluorescence test for syphilis, Nucleic acid based diagnostic techniques: Rapid PCR and RT-PCR.

Anti-microbial chemotherapy: General characteristics and mode of action of anti-microbial agents. Antibacterial with one example each: inhibitor of nucleic acid synthesis, inhibitor of cell wall synthesis, inhibitor of cell membrane function, inhibitor of protein synthesis. Antifungal: mechanisms of action of amphotericin B, griseofulvin. Antiviral: mechanism of action of amantadine, tamiflu, acyclovir. Antimicrobial resistance: mechanisms of drug resistance, MDR, XDR, TDR, NDM-1, ESBL, MRSA, VRSA, ESKAPE pathogens.

Practical component

UNIT 1: (16 hours)

Identification and analysis of the cultural, morphological and biochemical characteristics of bacteria: E. coli, Salmonella, Pseudomonas, Staphylococcus, Bacillus, Klebsiella (any three).

Study of the composition and use of important differential media for identification of bacteria: mannitol salt agar, deoxycholate citrate agar / Salmonella Shigella (SS) agar, MacConkey / EMB Agar.

Identification of bacteria based on biochemical characteristics: IMViC (Indole test, Methyl Red test, Voges-Proskauer test, Citrate test), Triple Sugar Iron (TSI) test, nitrate reduction test, urease test and catalase test.

Group project: Study of skin microbiome: Study of the bacterial flora of skin by swab method: Isolation of bacteria from skin on general purpose media (nutrient agar) and/or selective media (mannitol salt agar). Study of colony characteristics of the obtained isolates followed by Gram staining and microscopy to determine the gram character, shape and arrangement of cells.

Unit 2: (14 hours)

Study of antibiotic sensitivity and rapid detection of infectious diseases: Principle and performance of antibacterial sensitivity test by Kirby-Bauer method. Concept of MIC values. Determining MIC of any two antibiotics for any two bacteria.

Principles and working of rapid antigen tests. Demonstration of lateral flow kit for rapid antigen detection of COVID19. Principle and working of antibody detection test: Dengue test / Widal test for typhoid.

Essential/recommended readings

Theory:

1. Brock Biology of Microorganisms by M.T. Madigan,J. Aiyer,D. Buckley,W.Sattley and D. Stahl.16th edition. Pearson, USA. 2021.
2. Prescott's Microbiology by J. M. Willey, K. Sandman and D. Wood. 11th edition. McGrawHill Higher Education, USA. 2019.
3. Textbook of Microbiology by R. Ananthanarayan and C.K.J. Paniker. 10th edition. Universities Press, India. 2017.
4. Jawetz, Melnick and Adelberg's Medical Microbiology by K.C. Carroll, S.A. Morse, T.A.Mietzner and S. Miller. 27th edition. McGraw Hill Education. 2016.
5. Microbiology: An Introduction by G.J. Tortora, B.R. Funke and C.L. Case. 9thedition.Pearson Education, USA. 2007.
6. DNA microarrays for the diagnosis of infectious diseases by E. Donatin E and M. Drancourt. Med Mal Infect. 2012; 42(10):453-459. Doi:10.1016/j.medmal.2012.07.017

Practicals:

1. A Handbook of Practical and Clinical Immunology Volumes I & 2 by G. P. Talwar and S.K. Gupta. 2nd edition. CBS Publishers, India. 2017.
2. Practical Immunology, A Laboratory Manual by S. Balakrishnan, K. Karthik and S. Duraisamy. Lambert Academic Publishing, India. 2017.
3. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 11th edition. Pearson Education, USA. 2016.
4. Laboratory Manual on Immunology and Molecular Biology by D. Dwivedi and V. Singh. Lambert Academic Publishing, India. 2013.
5. Practical Immunology by F.C. Hay, M.R. Olwyn and M.R. Westwood. 4th edition. Wiley Blackwell Publishing. 2002.

Suggestive readings

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SEMESTER-VI

B.Sc. (Hons.) Microbiology

DISCIPLINE SPECIFIC CORE COURSE – 16: PRINCIPLES OF MOLECULAR BIOLOGY-II

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSC601: PRINCIPLES OF MOLECULAR BIOLOGY-II	4	3	0	1	Class XII pass with Biology/ Biotechnology/ Biochemistry	Principles of Molecular Biology-I

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is for the student to gain comprehensive knowledge of the basic concepts of molecular biology.
- The student will become familiar with DNA-related cellular processes and will become aware of the central dogma of molecular biology, learning about the propagation of information through DNA replication and the unidirectional flow of information from DNA to RNA to proteins through transcription and translation.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to explain RNA processing events including capping, polyadenylation and splicing. Can discourse on the concepts of RNA interference through siRNA and miRNA.
- Student will be able to discuss the mechanisms of translation of proteins in both prokaryotes and eukaryotes, and convey information about the inhibitors of protein synthesis.
- Student will be able to analyze and explain various mechanisms of gene regulation in prokaryotes and eukaryotes at the level of transcription and post-transcriptional

processes, as well as epigenetic mechanisms of gene regulation through chromatin modifications, the role of lncRNAs in gene regulation.

- Student will be able to demonstrate the procedure of isolation and analyze RNA by colorimetric and spectrophotometric methods, resolve proteins by electrophoresis on SDS-PAGE.

SYLLABUS OF DSC-16

UNIT – I (15 hours)

RNA processing and its applications: Difference in structure of prokaryotic and eukaryotic mRNA. Split gene theory, introns and exons. Processing of eukaryotic mRNA: capping and polyadenylation mechanisms and enzymes involved. RNA splicing: Group I and Group II introns and the mechanisms of splicing linked to them. Spliceosome machinery. Concepts of alternative splicing and trans-splicing. Processing of rRNA. RNA interference and its significance. Brief overview of siRNA and miRNAs.

UNIT – II (14 hours)

Translation in prokaryotes and eukaryotes: Translational machinery: ribosome structure in prokaryotes and eukaryotes, tRNA structure, aminoacyl tRNA synthetases and charging of tRNA. Mechanism of initiation, elongation and termination of polypeptide synthesis in prokaryotes and eukaryotes, highlighting the differences in the processes between the two groups of organisms. Mechanisms for maintaining the fidelity of translation.

UNIT – III (16 hours)

Regulation of gene expression in prokaryotes and eukaryotes: Principles of transcriptional regulation in prokaryotes: negative versus positive regulation using lac, trp and ara operons as examples. Gene regulation during sporulation in Bacillus. Yeast mating-type switching. Mechanisms of epigenetic regulation of gene expression: regulation of gene expression by DNA methylation, histone acetylation and histone methylation. Regulation of gene expression by DNA methylation in prokaryotes versus in eukaryotes. Histone methylation as both, positive as well as negative regulator of gene expression. Gene regulation by long noncoding RNAs (lncRNAs).

Practical component

UNIT 1: (15 hours)

Analysis of RNA and its applications:

RNA isolation and estimation: Total RNA isolation from yeast / bacterial cells. Colorimetric analysis of RNA with yeast tRNA as standard, using orcinol reagent or UV spectrophotometry. Northern blot analysis of processed RNA through virtual lab.

Student group research study project: use of mRNA in vaccines – case study of the COVID19 mRNA vaccines: CCMB vaccine technology/platform (based on Pfizer-

BioNTech/Moderna technology) versus Gennova vaccine technology/platform (based on HDT Bio Corp technology)
or
Student group research study project: trans-splicing in trypanosomatids.

Unit 2: (15 hours)
Analysis of proteins:
Analysis of total cell protein of bacteria by SDS-PAGE.
Student group research study project: drugs that inhibit protein translation and their mechanism of action.

Essential/recommended readings

Theory:

1. Lewin's Essential Genes by J. Krebs, E. Goldstein and S. Kilpatrick. 4th edition. Jones andBartlett Publishers, USA. 2020.
2. Karp's Cell and Molecular Biology by G. Karp, J. Iwasa and W. Marshall. 9th edition. Wiley, USA. 2019
3. Molecular Biology by D. Clark, N. Pazdernik and M. McGehee. 3rd edition. Academic Cell, USA. 2018.
4. Lewin's Genes XII by J. Krebs, E. Goldstein and S. Kilpatrick. 12th edition. Jones and BartlettLearning, USA. 2017.
5. Becker's World of the Cell by J .Hardin and G.P. Bertoni. 9th edition. Pearson, USA. 2015.
6. Principles of Genetics by D.P. Snustad and M.J. Simmons. 7th edition. Wiley and Sons, UK. 2015.
7. Molecular Biology of the Gene by J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levine and R. Losick. 7th edition. Pearson Education, USA. 2014.
8. Cell and Molecular Biology by E.D.P. De Robertis and E.M.F. De Robertis. 8th edition. Lippincott Williams and Wilkins, USA. 2006.

Practicals:

1. Molecular Cloning: A Laboratory Manual by M. Green and J. Sambrook Volumes 1-3. 4th edition. Cold Spring Harbor Laboratory Press, USA. 2012.
2. An Introduction to Practical Biochemistry by D. Plummer. 3rd edition. McGraw Hill Education, India. 2017.

Suggestive readings

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 17: ADVANCES IN IMMUNOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSC602: **ADVANCES IN IMMUNOLOGY**	**4**	**3**	**0**	**1**	**Class XII pass with Biology/ Biotechnology/ Biochemistry**	**Basic concepts of Immunology**

Learning Objectives

The Learning Objectives of this course are as follows:

- The main objective of this course is to provide a detailed insight to the student about crucial roles played by human immune system in generation of an optimum immune response as well as in serious conditions arising by immune dysfunction such as infections, hypersensitivity, immunodeficiency and autoimmunity.
- Also the importance of immune system in cases of cancer and organ transplant. The course further enhances the student's understanding of how various immunodiagnostics and other advances in immunology have changed the face of modern medicine.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to discuss the generation of humoral and cell-mediated immune response and the killing mechanisms available within the host body.
- Student will be able to describe immunity disorders like hypersensitivity, autoimmunity and immunodeficiency.
- Student will be able to explain organ transplantation and the role of the immune system in acceptance or rejection of the grafts, and ways to manage it.
- Student will be able to describe types of cancers, the antigens and immune response involved, tumor evasion mechanisms, diagnosis and treatment.
- Student will be able to describe vaccine formulation and its types, adjuvants, and National Immunization Schedule.

SYLLABUS OF DSC-17

UNIT – I (12 hours)

Generation of Immune Response: B cell development, generation of humoral immune response, primary and secondary immune response, generation of cell-mediated immune response (TCR, Self MHC restriction, T cell activation, co-stimulatory signals), killing mechanisms by CTL and NK cells.

UNIT – II (12 hours)

Immune Dysfunction: Types of hypersensitivities with one examples each, mechanism, manifestations and detection of type I hypersensitivity; Autoimmunity: types and mechanisms (Hashimoto's thyroiditis, Goodpasture's syndrome, IDDM, Rheumatoid arthritis, Multiple sclerosis, SLE); Immunodeficiency: Animal models (nude and SCID mice), disorders (SCID, DiGeorge syndrome, Chediak- Higashi syndrome, LAD, CGD).

UNIT – III (8 hours)

Transplantation Immunology: Types of grafts (autograft, isograft, allograft & xenograft), HLA typing, immunologic basis of graft rejection (sensitization & effector stages), role of T cells in graft rejection, GVHD, clinical manifestations of graft rejection (hyperacute, acute and chronic rejection), immunosuppressive therapies (general and specific), immunoprivileged sites

UNIT – IV (8 hours)

Cancer Immunology: Immune surveillance, types of cancers, malignant transformation of cells, tumor antigens (TATA and TSTA), immune response to cancer, tumor evasion, immunodiagnosis and cancer immunotherapy

UNIT – V (5 hours)

Vaccines: Active immunization, designing vaccines, boosters, types of vaccines: live attenuated, toxoid, conjugate/ multivalent, subunit, peptide, recombinant (vector based), DNA and RNA vaccines, use of adjuvants, National Immunization Schedule (NIS).

Practical component

UNIT 1: (20 hours)

Immunological techniques based on antigen - antibody interactions: Principles, working methods and applications of the following immunological techniques: ELISPOT, western blotting, immunofluorescence, flow cytometry, immunoelectron microscopy. Performance of SDS-PAGE to separate the different types of immunoglobulins. Detection of Type I hypersensitivity by RIST and RAST. MLR and Microcytotoxicity tests for HLA typing using pictures.

Unit 2: (12 hours)

Student group research studies:

Student group research project I: Experimental Systems in Immunology: Primary lymphoid cell culture systems. Animal models: Nude mouse, SCID mouse, SPF (Specific Pathogen Free) colony mice, dirty mice.

Student group research project II: short-term and long-term immune response to COVID-19 vaccines: case study of Covaxin.

Essential/recommended readings

Theory:

1. Immunology: A short course by R. Coico. 8th edition. Wiley- BlackwellScientific Publication, UK. 2021
2. Cellular and Molecular Immunology by A.K. Abbas, A.H. Lichtman and S. Pillai. 10th edition.Elsevier, USA. 2021.
3. Kuby Immunology by J. Punt, S. Stranford, P. Jones and J. Owen. 8 th edition.
4. W.H. Freemanand Company, USA. 2018.
5. Roitt's Essential Immunology by P. Delves, S. Martin, D. Burton and I.M. Roitt. 13th edition.Wiley- Blackwell Scientific Publication, UK. 2017.
6. Janeway's Immunobiology by K. Murphy and C. Weaver. 9th edition. Garland Science Publishers, USA. 2016.
7. Basic and Clinical Immunology by M. Peakman and D. Vergani. 2nd edition. ChurchillLivingstone, UK. 2009.
8. Immunology by C. Richard and S. Geoffrey. 6th edition. Wiley- Blackwell Scientific Publication, UK. 2009.

Practicals:

1. A Handbook of Practical and Clinical Immunology Volumes I & 2 by G. P. Talwar and S.K. Gupta. 2nd edition. CBS Publishers, India. 2017.
2. Practical Immunology, A Laboratory Manual by S. Balakrishnan, K. Karthik and S. Duraisamy. Lambert Academic Publishing, India. 2017.
3. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 11th edition. Pearson Education, USA. 2016.
4. Laboratory Manual on Immunology and Molecular Biology by D. Dwivedi and V. Singh. Lambert Academic Publishing, India. 2013.
5. Practical Immunology by F.C. Hay, M.R. Olwyn and M.R. Westwood. 4th edition. Wiley Blackwell Publishing. 2002.

Suggestive readings

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE –18: INDUSTRIAL MICROBIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
MICROB-DSC603: INDUSTRIAL MICROBIOLOGY	4	3	0	1	Class XII pass with Biology/ Biotechnology/ Biochemistry	None

Learning Objectives

The Learning Objectives of this course are as follows:

- The major objective of this course is to give students an overview of the applications of fermentation processes in industry.
- The students will gain in-depth knowledge of different types of fermentation processes, fermenter designs and operations. They will become aware of large scale culturing methods of microorganisms for production of bioactives of industrial importance.
- Students will also gain an insight into steroid biotransformation and enzyme immobilization

Learning outcomes

The Learning Outcomes of this course are as follows:

- Student will be able to describe important developments in industrial microbiology and explain different types of fermentation processes.
- Student will be able to discuss the design, operations and applications of different types of fermenters and the measurement and control of fermentation parameters.
- Student will be able to demonstrate use of various methods to isolate, screen, preserve and maintain industrially important microbial strains, the different types of media used in fermentation processes.
- Student will be able to demonstrate use of various techniques for the recovery and purification of industrial products produced by microorganisms.
- Student will be able to explain the principles of large-scale microbial production and recovery of industrial products.
- Student will be able to demonstrate microbiological transformations of steroids and use the methods of enzyme immobilization to exploit their advantages and applications in the industry.

SYLLABUS OF DSC-18

UNIT – I (7 hours)

Development of industrial microbiology: Important developments in industrial microbiology and contribution of following scientists: Louis Pasteur, Carl Wilhelm Scheele, Casimir Funk, Alexander Fleming, Selman A. Waksman, Howard W Florey and Ernst B Chain. Types of fermentation processes: aerobic and anaerobic fermentations, solid-state and liquid-state (stationary and submerged) fermentations, batch, fed-batch and continuous fermentations

UNIT – II (10 hours)

Bioreactors and analysis of fermentation parameters: Parts of a typical fermenter. Types of bioreactors and their applications: Laboratory, pilot-scale and production fermenters, continuously stirred tank reactor, air-lift fermenter. Measurement and control of parameters: pH, temperature, dissolved oxygen, foaming and aeration.

UNIT – III (7 hours)

Selection of industrially important microbial strains: Sources of industrially important microorganisms, their isolation and screening (primary and secondary). Preservation and maintenance of stock and working cultures. Crude and synthetic fermentation media, inoculum and production media. Crude media components: molasses, corn-steep liquor, sulphite- waste liquor, whey, yeast extract. , peptone and tryptone.

UNIT – IV (4 hours)

Recovery methods for fermentation products: Physiochemical and biological methods for cell disruption, centrifugation, batch filtration, precipitation, solvent-solvent extraction spray drying and lyophilization.

UNIT – V (17 hours)

Upstream and downstream processing of microbial products, steroid biotransformation and enzyme immobilization: Citric acid, ethanol, glutamic acid, Vitamin B12, Wine (white, rose & red), beer, antibiotics (penicillin,streptomycin) and enzymes (amylase, protease, lipase and glucose oxidase). Microbiological transformation of steroids and its applications. Methods of enzyme immobilization: cross linking, entrapment, adsorption and covalent bonding. Advantages and applications of immobilized enzymes: glucose isomerase and penicillin acylase

Practical component

UNIT 1: (18 hours)

Aerobic fermentation processes: Microbial production of enzymes (amylases/lipase/protease) by liquid-state static /submerged fermentation and its detection by plate-assay method using an agar-based medium. Estimation of enzyme activity spectrophotometrically. Production of amino acids (glutamic acid /lysine) using a suitable bacterial culture, its detection by paper chromatography and its

colorimetric estimation using buffered ninhydrin reagent. Microbial production of citric acid by solid-state /liquid state fermentation using Aspergillus niger, its detection by chromatographic techniques and its quantitative estimation by titration.

Unit 2: (12 hours)

Anaerobic fermentation processes: Ethanol production by submerged fermentation using Saccharomyces cerevisiae, its detection by qualitative tests and its estimation spectrophotometrically using a suitable reagent.

A visit to any educational institute/industry to understand different types of fermenters/ bioreactors: laboratory-scale, pilot-scale and production fermenter, and their components (spargers, baffles, impellers etc

Essential/recommended readings

Theory:

1. Industrial Microbiology by A.H. Patel. 2nd edition. Laxmi publication Pvt Ltd/Trinity Press. 2022.
2. Industrial Microbiology by L.E. Casida. 2nd edition. New Age International publisher. 2019.
3. Modern Industrial Microbiology and Biotechnology by N. Okafor and B.C. Okeke. 2nd edition. CRC press, UK. 2018.
4. Crueger's Biotechnology: A Textbook of Industrial Microbiology by W. Crueger,

A. Crueger and K.R.Aneja. 3rd edition. Medtech Publisher, India. 2017.

5. Biotechnology Industrial Microbiology. A textbook by W.Clarke. CBS Publishers, India.2016.
6. Industrial Microbiology by K.L. Benson. CBS Publishers & Distributors. 2016.
7. Principles of Fermentation Technology by P.F. Stanbury, A.Whitaker and S.J. Hall. 3rd edition. Elsevier Science Ltd, Netherlands. 2016.
8. 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.
9. Industrial Microbiology: An Introduction by M.J. Waites, N.L. Morgan, J.S . Rockey and G.Higton. Wiley –Blackwell. 2001.
10. Microbial Biotechnology: Fundamentals of Applied Microbiology by A.N. Glazer and H.Nikaido. 1st edition. W.H. Freeman and Company, UK.1995.

Practicals:

1. Microbiology: A Laboratory Manual by J. Cappuccino and C.T. Welsh. 12th edition. Pearson Education, USA. 2020.
2. Laboratory manual of Microbiology and Biotechnology by K.R. Aneja. 2nd edition. Scientific International Pvt. Ltd., Delhi. 2018.
3. Manual of Industrial Microbiology and Biotechnology edited by R.H. Baltz, A.L. Demain, and J.E. Davies. 3rd edition. American Society for Microbiology. 2010.
4. Microbial technology. Vol I- Microbial processes and Vol II -Fermentation technologyedited by H.J. Peppler and D. Perlman. 2nd edition. Academic Press, USA. 2009.

Suggestive readings

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.