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.

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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.

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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.

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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.**