School of Basic Sciences and Research

Department of Life Science

Program Structure: Three Year UP Higher Education for Microbiology Discipline

AY: 2021-22 Onwards

1.1 Vision, Mission and Core Values of the University

Vision of the University

To serve the society by being a global University of higher learning in pursuit of academic excellence, innovation and nurturing entrepreneurship.

Mission of the University

1. **Transformative educational experience**
2. **Enrichment by educational initiatives that encourage global outlook**
3. **Develop research, support disruptive innovations and accelerate entrepreneurship**

Core Values

- **Integrity**
- **Leadership**
- **Diversity**
- **Community**

1.2 Vision and Mission of the School

Vision of the School

Achieving excellence in the realm of basic and applied sciences to address the global challenges of evolving society

Mission of the School

1. **To equip the students with knowledge and skills in basic and applied sciences**
2. **Capacity building through advanced training and academic flexibility.**
3. **To establish centre of excellence for ecologically and socially innovative research.**
4. **To strengthen interinstitutional and industrial collaboration for skill development and global employability.**

1.3 Vision and Mission of Department of Life Sciences

Vision of Life Sciences Department

Strive to achieve excellence in teaching and research in the field of Microbiology and Biotechnology and to build human resource for solving contemporary problems.

Mission of Life Sciences Department

- **Providing distinctive and relevant education in Life Sciences to students.**
- **Motivating young minds through innovative teaching methods, to acquire theoretical knowledge and practical skills in different disciplines ofchemistry and empowering them with problem solving skills.**
- **Nurturing innovation by carrying out world class research and scholarly work**

1.4 Programme Educational Objectives (PEO)

PEO 1: Providing distinctive and relevant knowledge in Microbiology to students through innovative teaching methods.

PEO 2: Motivating young minds to acquire theoretical knowledge and practical skills in diversified disciplines of Microbiology and empowering them with problem solving skills through knowledge acquired.

PEO 3: Encouraging interdisciplinary research in collaboration with National/ International laboratories/institutes/research and technology organizations.

PEO 4: Inculcating scholarly research aptitude and innovative approach among students.

PEO 5: Imparting ethical understanding about safe handling of chemicals and various issues related to microbiological/biochemical processes.

PEO 6: Applying Microbiology as an integral approach to address environmental and societal issues.

PEO 7: Providing education to bridge the research gaps through various advanced toolsand techniques.

1.4.2 Map PEOs with Mission Statements:

PEO Statements	School Mission 1	School Mission 2	School Mission 3	School Mission 4
PEO1	3	3	1	2
PEO2	2	2	3	2
PEO3	2	3	3	3
PEO4	1	1	3	2
PEO5	1	2	3	2
PEO6	3	2	3	1
PEO7	2	2	3	3

1. **Slight (Low) 2. Moderate (Medium) 3. Substantial (High)**

1.4.3 Program Outcomes (PO's)

PO1: Ability to gain knowledge of microbiology with a thorough understanding in Bacteriology, virology and its sub-disciplines such as biomolecules, cell biology, enzymology,genetics and molecular biology.

PO2: Capacity to identify problems and formulate appropriate strategy to find solutions by applying analytical and rational thinking.

PO3: Capability to combine the knowledge in Microbiology with chemical technology, biophysics and biochemistry to solve problems of interdisciplinary nature.

PO4: Attainment of skill in problem solving, critical thinking and analytical reasoning as applied to scientific problems.

PO5: Acquirement of expertise in understanding and appreciating the central role of biochemistry in our society and use this as a basis for ethical behavior in issues facing chemists such as safe handling of chemicals, environmental issues and key issues facing our society in energy, health and medicine.

PO6: Ability to explain why biochemistry is an integral activity for addressing social and environmental problems.

PO7: Competency in using modern library search tools to locate and retrieve scientific information.

1.4.4 Mapping of Program Outcome Vs Program Educational Objectives

	PEO1	PEO2	PEO3	PEO4	PEO5	PEO6	PEO7
PO1	3	3	3	2	2	3	1
PO2	2	3	3	1	1	2	2
PO3	2	3	3	3	1	2	2
PO4	1	1	3	3	2	1	3
PO5	2	2	2	3	3	3	2
PO6	1	1	1	3	2	3	2
PO7	1	2	2	3	1	1	3

1. Slight (Low) 2. Moderate (Medium) 3. Substantial (High)

B. Program Structure

1. TITLE: Three Year UP Higher Education Program Structure forMicrobiology Discipline

2. DURATION OF THE COURSE: 3 Years

3. YEAR OF IMPLIMENTATION

This syllabus will be implemented for the session academic year 2021-22 onwards.

4. PREAMBLE

Total Credits- 150

Minimum credit required for multiple entry and exit:

Total credit of the 03-year UG Program for year wise multiple entry and exit	01st Year	46
	02nd Year	96
	03rd Year	146

Total Number of Semesters – 06 (Two semesters per year)Total

Number of Theory Papers – 28

Total Number of Practical courses – 20

Total Number of Minor Projects/Dissertations- 02

Number of papers (theory) per semester – 04-05

Number of Laboratory courses per semester – 02-04

Community Connect: 01

Internship: 01

Semester wise subjects

No.	Course Name	Subject	Theory/ Practical	Credit		(Min.-Max. Total Credits) After completion {Minimum Credits} [Max Duration in years]
				Total	Min. - Max.of the semester/year	
Year01: Certificate in Basic Microbiology (CBM)						
1.	**Semester 1**	Fundamentals of Biochemistry	MajorI	Theory	4	23	(46-50) {46} [4] Certificate in Basic Microbiology (CBM)
2.		Introduction to Microbiology	MajorI	Theory	4	
3.		Chemistry - I	Major II	Theory	4	
4.		Vocational Course	Major II	Practical	3	
5.		Food and Nutrition	Major III	Theory/Practical	2	
6.		Biochemistry Lab (C)	Major III	Practical	2	
7.		Microbiology Lab	Vocational	Practical	2	
8.		Chemistry Lab - I	Co-curricular	Practical	2	
Total credit					**23**		
1.	**Semester 2**	Cell and Molecular Biology	Major I	Theory	4	23-27	
2.		Bioinstrumentation	Major I	Theory	4	
3.		Chemistry - II	Major II	Theory	4	
4.		Physics - I	Major II	Theory	4	
5.		Vocational Course	Major III	Practical	3	
6.		Health and Hygiene	Major III	Theory/Practical	2	
7.		Molecular biology Lab(C)	Minor/ Elective	Practical	2	
8.		Bioinstrumentation Lab	Vocational	Practical	2	
9.		Chemistry Lab - II	Co-curricular	Practical	2	
Total credit					**27**		
Year02: Diploma in Microbiology (DMB)						
1.		Genetics	Major I	Theory	04		

2.		Genetics Lab	Major I	Practical	02		
3.		Molecular Biology-I	Major II	Theory	04		
4.		Molecular Biology Lab-I	Major II	Practical	02		
5.	**Semester3**	Chemical Dynamics and Coordination Chemistry/Animal Biotechnology	Major III	Theory	04	23-27	
6.		Physical Analysis Lab/ Animal Biotechnology Lab	Major III	Practical	02		
7.		Statistics-I/Food Science/ Basics of Pharmaceuticals	Minor/ Elective	Theory	04		
8.		Biochemical and analytical Trends in Biochemistry-III	Vocational	Practical	03		
9.		Physical Education	Co-curricular	Theory	02		
Total credit					**27**		96-100 {96} [7] Diploma in Enzymology and Molecular Biology
1.		Enzymology	Major I	Theory	04		
2.		Enzymology Lab	Major I	Practical	02		
3.		Molecular Biology-II	Major II	Theory	04		
4.		Molecular Biology Lab-II	Major II	Practical	02		
5.	**Semester4**	Analytical Techniques / Chemistry in Action/ Bioinformatics	Major III	Theory	04	23	
6.		Instrumental Analysis/ Chemistry in Action Lab/ Bioinformatics lab	Major III	Practical	02		
7.		Biochemical and analytical Trends in Biochemistry-IV	Vocational	Practical	03		
8.		Human values and Environment Studies	Co-curricular	Theory	02		
Total credit					**23**		
Year 03: Degree in Bachelor of Science							
1.		Intermediary Metabolism	Major I	Theory	04		
2.		Immunology	Major I	Theory	04		
3.		Immunology Lab	Major I	Practical	02		
4.	**Semester5**	Research Project (will be undertaken as a part of internship after semester 4)	Industrial Training/ Survey/ Project	Project	01	25	
5.		Hormonal Biochemistry	Major II	Theory	04		

6.		Proteins	Major II	Theory	04		(146-150) {146) [10] Degree in Bachelor of Science
7.		Proteins Lab	Major II	Practical	02		
8.		Analytic Ability and Digital Awareness	Co-curricular	Theory	02		
9.		Community connect	Industrial Training/ Survey/ Project	Project	02		
Total credit					25		
1.	**Semester6**	Tools and techniques in Biochemistry	Major I	Theory	04	25	
2.		Recombinant DNA Technology	Major I	Theory	04		
3.		Recombinant DNA Technology Lab	Major I	Practical	02		
4.		Research Project	Industrial Training/ Survey/ Project	Project	03		
5.		Membrane Biochemistry and Bioenergetics	Major II	Theory	04		
6.		Cell signaling and Cancer Biology	Major II	Theory	04		
7.		Advance Biochemistry Lab	Major II	Practical	02		
8.		Communication Skills and Personality Development	Co-curricular	Theory	02		
Total credit					25		

Total credit of the 03-year UG Program: 150	01st Year	46-50	**Minimum credit required:** 146
	02nd Year	96-100	
	03rd Year	146-150	

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

Course outcomes:

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

CO1**:** Understand the basic concepts of bioenergetics and its role in the and functioning of a cell.

CO2**:** Know about the proteins and various types of it.

CO3**:** Explain about various nucleic acid molecules and DNA structure types that exists in nature.

CO4**:** Understand the cell membranes and mode of transportation across them.

CO5: Understand how cell functions when it receives a signal and how the cell cycle is regulated.CO6: Apply his knowledge in understanding the cellular structure and cellular function.

CO7: Understanding of types of lipids and their synthesis

CO8: Understanding of types of carbohydrate and their synthesis

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

Unit	Topic	Total No. of Lectures (60)
I	**Bioenergetics and thermodyanamics** • Principles of Bioenergetics, Bioenergetics and Thermodynamics • Biological Oxidation-Reduction Reactions, Free Energy Calculations, The Cell's Energy Currency-Phosphoryl Group Transfers and ATP • Free-Energy-Driven Transport across Membranes	**7**
II	**Protein structure** • Primary Secondary and Tertiary structure, Quaternary • Structures • Fibrous and globular proteins, Protein-assisted folding and • chaperones in protein folding, protein targeting the physiological chemistry of oxygen binding bymyoglobin and hemoglobin, The regulatory compound, 2,3-bisphosphoglycerate (BPG)	**7**
III	**Nucleic Acids** • Structure and functions: Physical & chemical properties of Nucleic acids, Nucleosides & Nucleotides, purines &Pyrimidines • Biologically important nucleotides, Double helical model of DNA structure forces responsible for A, B & Z – DNA, denaturation and renaturation of DNA	**6**
IV	**Biological Membranes and Transport** • The Composition and Architecture of Membranes • Solute Transport across Membranes; transport of small • molecules, active and passive transport • Transport of macromolecules, Endocytosis, Phagocytosis, Pinocytosis	**8**

V	**Bio-signaling and hormones** • Molecular Mechanisms of Signal Transduction, Gated Ion Channels, Receptor Enzymes, G Protein-Coupled Receptors and Second Messengers • Regulation of transcription by steroid hormones, • Regulation of the Cell Cycle by Protein Kinases • Secretion and functions of hormones of thyroid, pituitary and gonads.	**8**
VI	**Synthesis and metabolism of Purines and Pyrimidines** • Denovo synthesis for purines and pyrimidines • Salvage pathway for purines and pyrimidines • Inhibitors of purines and pyrimidine	**8**
VII	**Lipids** • Classification, structure, properties and functions of fatty acids, • Essential fatty acids, fats, phospholipids, sphingolipids, cerebrocides, steroids, bile acids, • Prostaglandins, lipoamino acids, lipoproteins, proteolipids, phosphatidopeptides, lipopolysaccharides.	**8**
VIII	**Carbohydrate and vitamins** • Classification, structure, general properties and functions of Monosacharides, • Different types of polysaccharides, homo and hetropolysacharides, steroids and sterols. • Dietary sources, biochemical functions, requirements and deficiency diseases associated with vitamin B complex, C and A, D, E & K vitamins.	**8**

Suggested Readings:

1. Nelson, D.L., Cox, M.M. (2004) Lehninger Principles of Biochemistry, 4th Edition, WH Freeman and Company,New York, USA.
2. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006). Biochemistry. VI Edition. W.H Freeman
3. Buchanan, B., Gruissem, W. and Jones, R. (2000) Biochemistry and Molecular Biology of Plants. AmericanSociety of Plant Biologists.

CO-PO mapping

Outcome no.→	1	2	3	4	5	6	7	8	9
Syllabus topic↓									
Unit1									
A	X								X
B	X								X
C	X								X
Unit2									
A		X							X
B		X							X
C		X							X
Unit3									
A			X						X
B			X						X
C			X						X
Unit4									
A				X					X
B				X					X
C				X					X
Unit5									
A					X				X
B					X				X
C					X				X
Unit 6									
A						X			X
B						X			X
C						X			X
Unit 7									
A							X		X
B							X		X
C							X		X
Unit 8									
A								X	X
B								X	X
C								X	X

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**3**	**2**	**3**	**1**	**1**	**3**	**1**
CO2	**3**	**2**	**3**	**1**	**1**	**3**	**1**
CO3	**3**	**2**	**3**	**1**	**1**	**3**	**1**
CO4	**3**	**2**	**3**	**1**	**1**	**3**	**1**

CO5	**3**	**2**	**3**	**1**	**1**	**3**	**1**
CO6	**3**	**2**	**3**	**1**	**1**	**3**	**1**
CO7	**3**	**2**	**3**	**1**	**2**	**3**	**1**
CO8	**3**	**2**	**3**	**1**	**2**	**3**	**2**

Programme/Class: Certificate	**Year: first**	**Semester: first**
Subject: Microbiology		
Course Code:	**Course Title: Introduction to Microbiology**	

Course outcomes:

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

CO1: To study the history of microbiology and its basic concepts.
CO2: To understand the various classification of bacteria
CO3: To study how bacteria can be classified based on its morphology, cell structure
CO4: Understand the growth in bacteria and how to isolate bacterial species
CO5: Understanding the ways to control microbial growth
CO6: Basic understanding of viruses
CO7: To know of microbial diversity in extreme environments
CO8: To know the cell composition of microbial species

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

Unit	Topic	Total No. of Lectures (60)
I	**Introduction to Microbiology** • History of Microbiology & contribution of Microbiologists • Spontaneous generation; Koch Postulates • Whittaker's 5 kingdom concept; Pasteurization.	**7**
II	**Classification of Bacteria** • Basis of microbial classification, molecular approaches in microbial classification, concept of microbial species; • Principle and classification of bacteria on the basis of Bergey's manual of Determinative bacteriology; Nutritional classification of Bacteria • Cyanobacteria and Prochlorons	**7**
III	**Morphology of Bacteria** • Morphology and fine structure of Bacteria; outer surface of bacteria; • Cell wall of Gram +ve and Gram –ve bacteria • Brief overview on Archaea; Cyanobacteria, PPLO	**6**
IV	**Growth and Sporulation in Bacteria** • Modes of cell division (Binary fission; budding and • Septum formation); Normal growth of bacteria; • Growth curve • Pure culture, Method of isolating pure culture • (Streak method, Pour-plate and spread plate technique); • Synchronous and asynchronous • Growth inhibitory substances (temperature, acidity, • alkalinity, water availability, oxygen)	**8**
V	**Control of Microbial Growth** • Microbes and Human welfare (medical and Chemical industry) • Microbes in food industry	**8**

	• Physical and chemical methods of control of Microorganisms	
VI	**Virus and its Control** • Ultra-structure of Virus • Life Cycle and its control • Life cycle of Bacteriophage	**8**
VII	**Microbial Diversity** • Microbial diversity and extremophiles: Microbial diversity, distribution ecological niche, abundance and density • Extremophiles – Psychrophiles, acidophiles, alkaliphiles, thermophiles, barophilesetc • non-culturable bacteria (Metagenomics). Methanogens, Methanotrophs and Methylotrophs	**8**
VIII	**Cell Composition** • Morphology and fine structure of Bacteria: Morphological types – size, shape and arrangements; • cell walls of archaea, Gram-negative, Gram-positive eubacteria, eukaryotes; L forms – cell wall synthesis, antigenic properties • Cell membranes – structure, composition and properties. Reserve materials, inorganic and organic inclusions.	**8**

Suggested Readings:

1. Microbiology- Pelczar, M.J. Reid, R.D. and E.C.S.Chan, Tata McGraw Hill, New Delhi.1977 (4th Edition)
2. Prescott, Harley and Kelvin – Microbiology,2nd ed. TMH Publication
3. General Microbiology: Roger & Strainer et.al.

CO-PO mapping

Outcomeno.→	1	2	3	4	5	6	7	8	9
Syllabustopic↓									
Unit1									
A	X								X
B	X								X
C	X								X
Unit2									
A		X							X
B		X							X
C		X							X
Unit3									
A			X						X
B			X						X
C			X						X

Unit4									
A				X					X
B				X					X
C				X					X
Unit5									
A					X				X
B					X				X
C					X				X
Unit 6									
A						X			X
B						X			X
C						X			X
Unit 7									
A							X		X
B							X		X
C							X		X
Unit 8									
A								X	X
B								X	X
C								X	X

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**3**	**2**	**3**	**2**	**1**	**3**	**2**
CO2	**3**	**2**	**3**	**2**	**1**	**3**	**1**
CO3	**3**	**2**	**3**	**2**	**1**	**3**	**1**
CO4	**3**	**2**	**3**	**1**	**1**	**3**	**1**
CO5	**3**	**2**	**3**	**2**	**1**	**3**	**1**
CO6	**3**	**2**	**3**	**2**	**1**	**3**	**1**
CO7	**3**	**2**	**3**	**2**	**2**	**3**	**1**
CO8	**3**	**2**	**3**	**1**	**2**	**3**	**2**

Program/Class: Certificate	**Year-First**	**Semester-First**
Subject: Microbiology		
Course Code: MSB 155	**Course title : Biochemistry Lab**	

Course Outcome

After finishing the course, the students will be able to

CO1: identify and distinguish between mono-, di-, and oligosaccharides present in different samples

CO2: able to perform enzyme kinetics

CO3: able to test activity of enzymes

CO4: able to test and analyse for nucleic acids

CO5: able to test and analyse for amino acids

CO6: able to test and analyse for proteins

CO7: able to test and analyse for Vitamins

CO8: able to test and analyse for Lipids

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

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

Unit	Topic	**Total No. of Lectures (60)**
I	• Practical based on estimation of carbohydrates • Colorimetric estimation of carbohydrates Quantitative estimation of carbohydrate	8
II	• Practical related to estimation of starch • Enzyme kinetics of amylase	**8**
III	• Practical related to Practical related to study of enzymes	**8**
IV	• Practical related to isolation and estimation of nucleic Acids • Qualitative estimation of nucleic acids • Quantitative estimation of nucleic acids	**7**
V	• Practical related to estimation and separation of aminoacids • Amino acid separation by thin layer chromatograph • Amino acid separation by paper chromatography	**8**
VI	• Detection of proteins • Estimation of Proteins	**7**
VII	• Detection of Vitamins • Estimation of Vitamins	**7**
VIII	• Detection of Lipids • Estimation of Lipids	**7**

Suggested Readings

Sawhney S.K. and Singh R. **Introductory Practical Biochemistry.**

CO-PO mapping

Outcome no.→	1	2	3	4	5	6	7	8	9
Syllabus topic↓									
Unit1									
A	X								X
B	X								X
C	X								X
Unit2									
A		X							X
B		X							X
C		X							X
Unit3									
A			X						X
B			X						X
C			X						X
Unit4									
A				X					X
B				X					X
C				X					X
Unit5									
A					X				X
B					X				X
C					X				X
Unit 6									
A						X			X
B						X			X
C						X			X
Unit 7									
A							X		X
B							X		X
C							X		X
Unit 8									
A								X	X
B								X	X
C								X	X

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO2	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO3	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO4	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO5	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO6	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO7	**3**	**2**	**3**	**2**	**2**	**3**	**2**

CO8	**3**	**2**	**3**	**2**	**2**	**3**	**2**

Program/Class: Certificate		**Year-First**	**Semester-First**
Subject: Microbiology			
Course Code: MMB153	**Course title: Microbiology Lab**		

Course Outcome
After finishing the course, the students will be able to
CO1: Isolation of pure colony
CO2: How to characterize bacteria on visible characteristics
CO3: learn gram staining
CO4: Acid fast technique principles
CO5: fermentation of carbohydrate by various bacterial species
CO6: importance of catalase
CO7: differential and cell staining
CO8: Assess bacterial growth curve

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

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

Unit	Topic	**Total No. of Lectures (60)**
I	• Isolation of individual cells from mixed culture	
II	• Characterization based on shape and size of microbial colonies	
III	• Gram Stain Techniques	
IV	• Acid Fast Staining	
V	• Carbohydrate Fermentation Test	
VI	• Catalase test	
VII	• Differential and Cytological Staining	
VIII		

	• Bacterial Growth Curve	

Suggesting Readings
Practical manual of Biotechnology by Ritu Mahajan, Jitendar Sharma, RK Mahajan, Vayu Education of India

CO-PO mapping

Outcome no.→	1	2	3	4	5	6	7	8	9
Syllabus topic↓									
Unit1									
A	X								X
B	X								X
C	X								X
Unit2									
A		X							X
B		X							X
C		X							X
Unit3									
A			X						X
B			X						X
C			X						X
Unit4									
A				X					X
B				X					X
C				X					X
Unit5									
A					X				X
B					X				X
C					X				X
Unit 6									
A						X			X
B						X			X
C						X			X
Unit 7									
A							X		X
B							X		X
C							X		X
Unit 8									
A								X	X
B								X	X
C								X	X

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7

CO1	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO2	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO3	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO4	**3**	**2**	**3**	**2**	**1**	**3**	**2**
CO5	**3**	**2**	**3**	**2**	**1**	**3**	**2**
CO6	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO7	**3**	**2**	**3**	**1**	**2**	**3**	**2**
CO8	**3**	**2**	**3**	**1**	**2**	**3**	**2**

Programme/Class: Certificate	**Year: First**	**Semester: Second**
Subject: Biotechnology		
Course Code:	**Course Title:** Cell and Molecular Biology	

Course outcomes:
The students at the completion of the course will be able to:
CO1: to understand about a cell and its evolution
CO2: Know about the detailed structure of a cell
CO3: How genetic information is stored in cells
CO4: To know about division of cells and its significance
CO5: To understand cell movements
CO6: To understand how genetic information flows through replication
CO7: To know RNA synthesis and regulation in prokaryotes
CO8: To understand regulation of gene expression

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

Unit	Topic	Total No. of Lectures (60)
I	**Cell and Cell theory** • Cell as a basic unit of life, Cell theory, Cell size and • Shape • Prokaryotic and Eukaryotic cells • Different types of cells	**7**
II	**Ultra-structure of cells** • Plasma membrane, Ribosomes • Protein sorting and transportation; Endoplasmic • Reticulum, Golgi Apparatus, Lysosomes; • Bioenergetics and metabolism, Mitochondria, • Chloroplast, peroxisomes	**7**
III	**Nucleus and Chromosomes** • Ultra-structure of nucleus, nuclear membrane • Chromosome structure, Centromeres, Telomeres • Euchromatin and heterochromatin, Polytene and • lampbrush chromosomes	**6**
IV	**Cell cycle** • Growth cycle and cell division • Mitosis, Meiosis • Significance of cell division	**8**
V	**Cytoskeleton and Cell-to-cell interaction** • Concept about cytoskeleton, microtubules, • microfilaments, intermediary filaments • Structure of cilia and flagella and their movement; • Cell to cell interaction	**8**
VI	**DNA Replication** • Replication process in prokaryotes • Replication process in eukaryotes • Enzymes and accessory proteins in replication, Replication of ss-circular DNA	**8**
VII	**Prokaryotic Transcription** • Process of prokaryotic and eukaryotic transcription • Inducible and constitutive promoters, • Operators and regulators in prokaryotic transcription	**8**

VIII	**Transcription and Regulation of Gene Expression** • Translation machinery, Ribosome, degeneracy of codons and termination codons • Mechanism of initiation, elongation and termination • Operon system, Lac operon and Trp operon.	8

Suggested Readings:

1. Cooper G.M.,and HausmanR.E., The Cell: A Molecular Approach, 5th Edition. Sinauer Associates (2009)
2. Karp G., Cell and Molecular Biology: Concepts and Experiments, 6th Edition. Wiley (2009).

CO-PO mapping

Outcomeno.→	1	2	3	4	5	6	7	8	9
Syllabustopic↓									
Unit1									
A	X								X
B	X								X
C	X								X
Unit2									
A		X							X
B		X							X
C		X							X
Unit3									
A			X						X
B			X						X
C			X						X
Unit4									
A				X					X
B				X					X
C				X					X
Unit5			X						
A			X		X				X
B			X		X				X
C			X		X				X
Unit 6									
A						X			X
B						X			X
C						X			X
Unit 7									
A							X		X
B							X		X
C							X		X
Unit 8									
A								X	X
B								X	X
C								X	X

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	1	1	3	1
CO2	3	2	3	1	1	3	1
CO3	3	2	3	1	1	3	1
CO4	3	2	3	1	1	3	1
CO5	3	2	3	1	1	3	1
CO6	3	2	3	1	1	3	1
CO7	3	2	3	2	1	3	1
CO8	3	2	3	2	1	3	1

Programme/Class: Certificate	**Year: First Year**	**Semester: Second**
Subject: Microbiology		
Course Code:	**Course Title: Bioinstrumentation**	

Course outcomes:

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

- CO1: To understand the concept and principle of microscopy
- CO2: To get a brief idea about common biotech lab instruments
- CO3: To discuss the principle of centrifugation and different types of centrifuges
- CO4: To understand the basic principle of chromatography and discuss different types of chromatographic techniques
- CO5: To discuss different types of electrophoresis and understand the principle of PCR and DNA sequencing
- CO6: To understand various radioisotopic techniques
- CO7: know about various biosensors and electrodes
- CO8: understand the principle of spectrospoic techniques

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

Unit	**Topic**	**Total No. of Lectures (60)**
I	**Common Instruments Usage and principle** • pH meter, Weighing balances • Usage and applications of horizontal and vertical autoclave • Laminar air flow, incubator, oven and rotary shaker	**7**
II	**Microscopy** • Simple, phase contrast, bright and dark field microscopy • Confocal and super resolution microscopy • Fluorescence and Electron microscopy (TEM and SEM))	**7**
III	**Centrifugation** • Principle of centrifugation, different types of centrifuge and rotors, • Types of rotors: fixed angle and swinging bucket rotors, • Bench top and high-speed centrifuges • Preparative, differential and density gradient centrifugation, Analytical centrifugation	**6**
IV	**Chromatographic techniques** • Liquid, column, and affinity chromatography • Thin layer and gel-filtration chromatography • Ion exchange and hydrophobic chromatography	**8**
V	**Electrophoresis and PCR** • Electrophoresis - principles and working, Gel • Electrophoresis- Immunoelectrophoresis, isoelectric focusing, capillary • Electrophoresis, 2D electrophoresis, Pulse field electrophoresis, • Polymerase Chain Reaction (PCR), DNA sequencing • (Sanger's Dideoxy method)	**8**
VI	**Radioisotopic Techniques** • Principles and application of tracer techniques in biology, radioactive isotopes. • Half-life of isotopes, cerenkov radiation, liquidscintillation, GM counter. • Effect of radiation on biological system, radioactive	**8**

		labeling of biological macromolecules, autoradiography and radiation dosimetry	
	VII	**Biosensors and Electrodes** • Basic techniques, enzyme electrodes, organic salt electrodes, immuno electrodes, microbial biosensors • Reference electrodes, The pO2 electrodes, Membrane electrodes, Blood gas analysis, Transcutaneous pO2 and pCO2 transducers, Fiber optic chemical transducer, Ion specific electrodes, Ionic content of blood, ISFET for glucose, urea.	**8**
	VIII	**Spectroscopy** • Spectroscopy – II and Thermal Analysis: Principles, Instrumentation & applications for flame emission / atomic absorption spectrophotometry and their comparative study; ICP (b) Mass spectrometry; Principles, Instrumentation and applications. Instrumentation and application of Differential scanning calorimetry and Thermogravimetry	**8**
	Suggested Readings: 1. Alka Gupta. Instrumentation &Bioanalytical Techniques. Pragati Edition 2. Subramanian M A. Biophysics: Principles and Techniques. MJP Publishers Ltd. 3. Cottenil, R M S. Biophysics: An Introduction. John Wiley& Sons Ltd, England, 2002.		

PO **CO-**

mapping

Outcome no.→	1	2	3	4	5	6	7	8	9
Syllabus topic↓									
Unit1									
A	X								X
B	X								X
C	X								X
Unit2									
A		X							X
B		X							X
C		X							X
Unit3									
A			X						X
B			X						X
C			X						X
Unit4									
A				X					X
B				X					X
C				X					X
Unit5			X						
A			X		X				X
B			X		X				X
C			X		X				X
Unit 6									

A						X			X
B						X			X
C						X			X

Unit 7									
A							X		X
B							X		X
C							X		X
Unit 8									
A								X	X
B								X	X
C								X	X

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	1	1	3	1
CO2	3	2	3	1	1	3	1
CO3	3	2	3	1	1	3	1
CO4	3	2	3	1	1	3	1
CO5	3	2	3	1	1	3	1
CO6	3	2	3	1	1	3	1
CO7	3	2	3	1	1	3	1
CO8	3	2	3	1	1	3	1

Program/Class: Certificate	**Year-First**	**Semester-Second**
Subject: Microbiology		
Course Code: MMB156	**Course title: Molecular Biology Lab**	

Course Outcome

After finishing the course, the students will be able to

- Demonstrate safe laboratory practices and handle the equipment safely.
- Estimate the quality and quantity of nucleic acids.
- Amalgamation of tools for plasmid vectors and DNA uptake.
- Understand concept of transformation
- Perform in-silico analysis for studying genome.
- Construct a phylogenetic tree
- To design primers and carry out amplification of DNA by PCR.
- To understand principle of PCR

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

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

Unit	Topic	**Total No. of Lectures (60)**
I	• **Practical based on introduction to molecular biology lab** • Good lab practices in molecular biology laboratory. • Preparation of standard solutions for molecular Biology experiments	**12**

II	• **Isolation of Nucleic acids and quantification** • Isolation of DNA from bacteria • Isolation of RNA from bacteria • Gel electrophoresis	**12**
III	• Practical related to preparation of plasmids and Transformations • Plasmid isolation	**12**
IV	• Preparation of competent cells • Transformation of plasmid into competent cells	**12**
V	• Practical related to in silico analysis of genome • Sequence similarity search with freely available tools •	**12**
VI	• Construction of phylogenetic tree • Identification of motifs and domain in sequences	
VII	• **Practical related to gene amplification** • Designing of primers for CDs and partial sequences	
VIII	• Performing PCR reactions	

Reading suggestions

Michael, R. G., Sambrook. J., "Molecular Cloning-A Laboratory Manual", 4th edition, Cold Spring Harbor Laboratory Press, 2012.
Davis, L. (2012). Basic methods in molecular biology. Elsevier.
Chard, T., Work, T. S., & Work, E. (1987). Laboratory techniques in biochemistry and molecular biology. Elsevier, Amsterdam.

CO-PO mapping

Outcome no.→	1	2	3	4	5	6	7	8	9
Syllabus topic↓									
Unit1									
A	X								X
B	X								X
C	X								X
Unit2									
A		X							X
B		X							X
C		X							X
Unit3									
A			X						X
B			X						X
C			X						X
Unit4									
A				X					X
B				X					X
C				X					X
Unit5									

A					X				X
B					X				X
C					X				X
Unit 6									
A						X			X
B						X			X
C						X			X
Unit 7									
A							X		X
B							X		X
C							X		X
Unit 8									
A								X	X
B								X	X
C								X	X

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	1	1	3	2
CO2	3	2	3	1	1	3	2
CO3	3	2	3	1	1	3	2
CO4	3	2	3	1	1	3	2
CO5	3	2	3	1	1	3	2
CO6	3	2	3	1	1	3	2
CO7	3	2	3	1	2	3	2
CO8	3	2	3	1	2	3	2

Program/Class: Certificate	**Year-First**	**Semester-Second**
Subject: Biotechnology		
Course Code: MMB156	**Course title: BioInstrumentation Lab**	

Course Outcome

After finishing the course, the students will be able to

- Operate autoclave, Laminar Air flow and Hot air oven and
- Sterilize glass and plastic wares.
- Understand how buffers are made
- Operate centrifuge and refrigerated centrifuge and separate cell components.
- Separate and visualize nucleic acids and proteins using gel electrophoresis.
- Operate spectrophotometer and perform absorbance assays.
- Separation of pigments, drugs, amino acids and hormones using chromatographic techniques.
- Operation and working of different instruments and bioanalytical Techniques

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

Total No. of Lectures-Tutorials-Practical (in hours per week): L-T-P: 0-0-4		
Unit	Topic	**Total No. of Lectures (60)**
I	**Practical based on Sterilization** • To learn the working of an autoclave. • To learn the working of a laminar air flow. • To sterilize glasswares using hot air oven.	**13**
II	**Practical related to centrifuge** • Using pH meter • Working and principle of incubator shaker • Working of refrigerated centrifuges	**13**
III	**Practical related to gel electrophoresis** • Separation of DNA using PAGE • Separation of proteins using PAGE	**13**
IV	Practical related to spectrophotometer • Principle and working of a spectrophotometer • Measuring concentration of protein using spectrophotometer	**13**
V	**Practical related to chromatography** • Use of paper chromatography for separation of plant pigments	**8**
Suggesting Readings 1. Wilson K. and Walker J., "Principles and Techniques of Biochemistry and Molecular Biology", Cambridge Press, 2010. 2. Cottenil R.M.S., "Biophysics: An Introduction", John Wiley and Sons, 2002. 3. Gupta A., "Instrumentation and Bioanalytical Techniques", Pragati Prakashan, 2009.		

CO-PO mapping

Outcome no.→	1	2	3	4	5	6	7	8	9
Syllabus topic↓									
Unit1									
A	X								X
B	X								X
C	X								X
Unit2									
A		X							X
B		X							X
C		X							X
Unit3									
A			X						X
B			X						X
C			X						X
Unit4									

A				X					X
B				X					X

C				X					X
Unit5			X						
A			X		X				X
B			X		X				X
C			X		X				X
Unit 6									
A						X			X
B						X			X
C						X			X
Unit 7									
A							X		X
B							X		X
C							X		X
Unit 8									
A								X	X
B								X	X
C								X	X

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO2	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO3	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO4	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO5	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO6	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO7	**3**	**2**	**3**	**2**	**2**	**3**	**2**
CO8	**3**	**2**	**3**	**2**	**2**	**3**	**2**

Three years UG programme structure of Microbiology as per UP Higher Education

		Subject I	**Subject II**	**Subject III**	**Subject IV**	**Vocational**	**Co-Curricular**	**Industrial Training/ Survey/ Project**			
		Major	**Major**	**Major(/ /Life Sciences)**	**Minor/Elective**	**Minor**	**Minor**	**Major**	**Credits**		
		Credits 4+2	**Credits** 4+2	**Credits** 4+2	**Credits** 4	**Credits** 3	**Credits** 2	**Credits**		**{Minimum Credits} [Max Duration In years]**	
Year		**Own Faculty**	**Own Faculty**	**Faculty**	**Other Department/ Faculty**	**Vocational Faculty**	**Co-Curricular Course**	**Inter/Intra Faculty related to main Subjects**	**Total**		
1	I	Fundamentalsof Biochemistry	Chemistryy - I	Introduction to Microbiology		Vocational Course	Food and Nutrition		23		
		Biochemistry Lab(C)	Chemistry Lab - I	Microbiology Lab							
		Cell and Molecular Biology	Bioinstrumentation	Chemistry - II	Physics - I	Vocational	Health and Hygiene		27		

		Molecular biology Lab(C)	Bioinstrumentation Lab	Chemistry Lab - II		Course				
2		Genetics		Chemistry - III	Physical Education and Yoga	Vocational	Bacteriology Lab		23	
		Bioprocess Lab	Bacteriology	Chemistry Lab - III						
		Genetic Engineering(C)	Metabolic Pathways	Chemistry - IV	Physics - II	Vocational	Human Values and Environmental Studies		27	
		Genetic Engineering Lab, Genetic Counselling &Telemedicine	Enzymology Lab	Chemistry Lab – IV						

3	V	Virology	Immunology	Enzyme Technology	Industrial Biotechnology	Analytic Ability and Digital Awareness	Community connect		25	
		Lab on Virtual Dissection, Anatomy, Economic Zoology and Parasitology	Nano-biotechnology Lab							
		Summer internship of term IV (Will be done after 4th Semester)								
	VI	Microbial Biotechnology	Mycology and Phycology	Environmental Biotechnology	Food and dairy Biotechnology	Research Project	Communication Skills and Personality Development	1(3)	25	
		Environmental Microbiology lab	Microbial Biotechnology Lab							

2nd Year

BSM201: Bacteriology

L-T-P 4-0-0 **Credit: 4**

School : SBSR		**Batch : 2019-2022**
Program: B.Sc.		**Current Academic Year: 2020-21**
Branch: Microbiology		**Semester: 3**
1	Course Code	**BSM201**
2	Course Title	**Bacteriology**
3	Credits	4
4	Contact Hours (L-T-P)	4-0-0
6	Course Objective	1. Morphology and Fine structure of Bacteria 2. Growth and Nutrition of Bacteria 3. Bacterial reproduction-asexual and sexual 4. Hypersensitivity and Autoimmunity
7	Course Outcomes	After studying this course, students will be able to CO1: Determine Size, shape and arrangement of bacterial cells CO2: Evaluate Continuous culture, Chemostat. Quantitative measurement of bacterial growth CO3: Interpret the Method of isolating pure culture, pour plate and spread plate technique CO4: AnalyseModes of cell division; Binary fission; Budding CO5: Determine Physical and chemical methods of control of Bacteria. CO6 : Analyze and study Mode of action of Anti-microbial agents
8	Course Description	This course contains various bacteriology concepts ranging from morphology, fine structure, growth nutrition of bacteria. After studying course, students will be able to learn modes of bacterial reproduction and genetics.

Unit 1	**Morphology and Fine structure of Bacteria**	CO1, CO6
A	Size, shape and arrangement of bacterial cells	
B	Structures external to the bacterial cell wall; cell wall composition of Gram Positive and Gram-Negative Bacteria	
C	Other organelles internal to cell wall; spore and cysts.	
Unit 2	**Growth and Nutrition of Bacteria**	CO2, CO6
A	Normal growth cycle (growth curve) of Bacteria; Factors responsible for bacterial growth, synchronous growth; Continuous culture, Chemostat.	
B	Quantitative measurement of bacterial growth (direct microscopic, plate count method); Method of isolating pure culture, pour plate and spread plate technique	
C	Nutritional requirements and types of bacteria.	
Unit 3	**Reproduction**	CO3, CO6

A	Bacterial reproduction-asexual and sexual		
B	Modes of cell division; Binary fission; Budding, fragmentation		
C	Formation of conidiophores; septum formation.		
Unit 4	**Bacterial Genetics**	CO4, CO6	
A	Phenotypic changes due to environmental Alterations; Genotypic changes; Mutation Types; Bacterial Recombination; Conjugation		
B	Molecular mechanism of gene transfer by conjugation; Hfr strains, mapping bacterial genomes using Hfr strains; Transduction; Bacterial Transformation, Natural transformation and competence		
C	Ti plasmid transfer system and its application in creating transgenics.		
Unit 5	**Microbes and human welfare**	CO5, CO6	
A	Microbes and Human welfare (medical, chemical and food industry)		
B	Physical and chemical methods of control of Bacteria		
C	Mode of action of Anti-microbial agents, factors responsible for controlling microbes, Physical and chemical agents.		
UNIT 6	**Methods of microbial control**		
	Physical methods of microbial control: heat, low temperature, high pressure, filtration, desiccation,osmotic pressure, radiation		
	Chemical methods of microbial control: disinfectants, types and mode of action		
Unit 7	**Bacterial systematics**		
	Aim and principles of classification, systematics and taxonomy, concept of species, taxa, strain; conventional, molecular and recent approaches to polyphasic bacterial taxonomy,		
	evolutionary chronometers, rRNA oligonucleotide sequencing, signature sequences, and protein sequences. Differences between eubacteria and archaebacteria		
Unit 8	**Important of archaeal groups**		
	Archaebacteria: General characteristics, phylogenetic overview, genera belonging to Nanoarchaeota(Nanoarchaeum), Crenarchaeota (Sulfolobus, Thermoproteus) and Euryarchaeota [Methanogens (Methanobacterium, Methanocaldococcus), thermophiles (Thermococcus, Pyrococcus, Thermoplasma), and Halophiles (Halobacterium, Halococcus)]		
Mode of examination	Theory		
Weightage Distribution	CA	MTE	ETE
	30%	20%	50%
Text book/s*	*Pelezar*, M.J. Reid, R.D. and E.C.S. Chan, (1986*) Microbiology* - Tata McGraw Hill, New Delhi.		
Other References	Mackie and McCartney (1996) Medical		

	Microbiology, Churchill Livingstone	

CO-POmapping

Outcomeno.→	1	2	3	4	5	6	7	8	9
Syllabustopic↓									
Unit1									
A	X								X
B	X								X
C	X								X
Unit2									
A		X							X
B		X							X
C		X							X
Unit3									
A			X						X
B			X						X
C			X						X
Unit4									
A				X					X
B				X					X
C				X					X
Unit5									
A					X				X
B					X				X
C					X				X
Unit6									
A						X			X
B						X			X
C						X			X
Unit7									
A							X		X
B							X		X
C							X		X
Unit8									
A								X	X
B								X	X
C								X	X

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	1	1	3	2
CO2	3	2	3	1	1	3	2
CO3	3	2	3	1	1	3	2
CO4	3	2	3	1	1	3	2
CO5	3	2	3	1	1	3	2
CO6	3	2	3	1	1	3	2
CO7	3	2	3	1	2	3	2
CO8	3	2	3	1	2	3	2

BSB108: Genetics

L-T-P: 4-0-0 **Credit: 4**

School: SBSR		**Batch : 2020-2023**
Program: B.Sc. (H)		**Current Academic Year: 2020-21**
Branch: Microbiology		**Semester: 02**
1	Course Code	BSB108
2	Course Title	Genetics
3	Credits	4
4	Contact Hours (L-T-P)	4-0-0
	Course Status	Compulsory
5	Course Objective	1. This course has been designed to make students understand the basic principles of classical Mendelian Genetics 2. To know about modern basis of heredity and to understand the transmission of characters via non-nuclear genes and effect of mutations on transmission of characters 3. Students understand the fine structure of gene and classical experiments that lead to the development of gene fine structure and its function
6	Course Outcomes	After the successful completion of this course students will be able to: CO1:describe various Mendelian laws as well as exception to these laws CO2:explain the structure of DNA, chromosomes and aberrations in chromosomes CO3: analyze extranuclear inheritance and examples to understand cytoplasmic inheritance CO4: describe mutation, its consequences and types CO5:demonstrate the fine structure of gene and experiments that lead to the understanding of gene structure and function CO6: describe basic principles of genetics and gene mutations and mechanisms of inheritance and heredity
7	Course Description	The 'Genetics' course outlines the basic principles of Classical Genetics. This course also sheds light upon modern genetics and is designed to make student learn the structure of chromosomes; nucleosomal organization of genetic material etc to understand the basis of heredity. The course also further encompasses the concept of mutation; extra nuclear inheritance of characters and effect of these phenomena on transmission of characters.

	Outline syllabus	CO Mapping
UNIT- 1		
	Brief overview of Mendel's work; Mendel's experimental design, monohybrid and	

	di-hybrid crosses; Mendel's Law of segregation & Law of independent assortment	CO1, CO6
	Verification of segregates by back and test crosses; Allelic interactions: Concept of dominance, recessiveness, incomplete dominance, co-dominance, semi-dominance, multiple allele, pseudo-allele, essential and lethal genes.	
	Non allelic interactions: epistasis (dominant & recessive), duplicate genes.	
UNIT-2	**Physical Basis of Inheritance**	
	Chromosome theory of inheritance; Eukaryotic Chromosome: Macromolecular Organization; packaging of DNA molecule into chromosomes	CO2, CO6
	Chromosome banding pattern, Heterochromatin and Euchromatin and its significance, karyotype; Chromosome types, primary and secondary constrictions; Centromere and Telomeres; Satellite -bodies	
	Variation in chromosome number Aneuploidy and Euploidy; Variations in chromosomes structure - deletion, duplication, inversion and translocation.	
UNIT-3	**Linkage and Crossing Over**	
	Concept of linkage and crossing over; Coupling and repulsion hypothesis; Linkage in maize and Drosophila; Linkage groups; Theories of linkage; Cis-Trans arrangement	CO3, CO6
	Crossing over and Genetic recombination	
	Extrachromosomal Inheritance: Maternal Inheritance: shell coiling in Limnaea; Inheritance of Mitochondrial DNA and Mitochondrial diseases in Human; Inheritance of Chloroplast DNA and Cytoplasmic Male Sterility (CMS) in crop plants	
UNIT-4	**Mutation**	
	Discovery of DNA as the genetic material	CO4, CO6
	Definition and types of mutations, Molecular basis of mutations	
	Ames test for mutagenic agents, screening procedures for isolation of mutants	
UNIT-5	**Fine Structure of Gene**	
	Benzer and T4 rII locus, Complementation test;	CO5, CO6
	Cistron, recon and muton	
	Beadle and Tatum's one gene one enzyme concept; One gene one polypeptide concept	
UNIT-6	**Genetics and cancer**	
	oncogenes- tumor inducing retroviruses and viral oncogenes; chromosome rearrangement and cancer; .	
	tumor suppressor genes- cellular roles of tumor suppressor genes, pRB, p53, pAPC, genetic pathways to cancer	
UNIT-7	**Sex determination & dosage compensation**	
	sex determination- in humans, Drosophila and other animals;	
	dosage compensation of X-linked genes– hyperactivation of X-linked gene in male Drosophila	
	inactivation of X-linked genes in female mammals	
UNIT-8	**Human genetics**	

	karyotype and nomenclature of metaphase chromosome bands		
	chromosome anomalies and diseases- chromosomal anomalies in malignancy (chronic myeloid leukemia, Burkitt's lymphoma,retinoblastoma and Wilms' tumor		
	genetic analysis of complex traits - complex pattern of inheritance, quantitative traits, threshold traits; human genome and mapping		
	Mode of examination	Theory	
	Weightage Distribution	CA	MT
		30%	20%
	Textbook/s*	1.	
	Other References	2. Hartl D.L. and Jones E.W, **"Genetics: analysis of genes and genomes".** Edition 5. Jones and Bartlett Publishers, 2000. 3. Gardner E.J., Simmons M.J., Snustad M.J., **"Principles of genetics".** Edition 8. John Wiley & Sons (Asia) Pte. Ltd., 2007.	
		1. Griffiths J.F., Wessler, S.R., Levonotin, R.C., Gelbart, W.M., Suzuki, D.T., Miller J.H., **"An Introduction to Genetic Analysis".** Edition 8.	

CO-POmapping

Outcomeno.→	1	2	3	4	5	6	7	8	9
Syllabustopic↓									
Unit1									
A	X								X
B	X								X
C	X								X
Unit2									
A		X							X
B		X							X
C		X							X

Unit3									
A			X						X
B			X						X
C			X						X
Unit4									
A				X					X
B				X					X
C				X					X
Unit5									
A					X				X
B					X				X
C					X				X
Unit6									
A						X			X
B						X			X
C						X			X
Unit7									
A							X		X
B							X		X
C							X		X
Unit8									
A								X	X
B								X	X
C								X	X

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO2	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO3	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO4	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO5	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO6	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO7	**3**	**2**	**3**	**1**	**2**	**3**	**2**
CO8	**3**	**2**	**3**	**1**	**2**	**3**	**2**

BSB205: Genetic Engineering

L T P: 4-0-0 **Credit: 4**

School: SBSR		**Batch: 2019-2022**
Program: B.Sc. (H)		**Current Academic Year: 2020-21**
Branch: Microbiology		**Semester: 4**
1	Course Code	**BSB205**
2	Course Title	**Genetic Engineering**
3	Credits	4
4	Contact Hours (L-T-P)	4-0-0
	Course Status	Compulsory
5	Course Objective	1.This course provides a comprehensive introduction to fundamentals and applications of genetic engineering 2. The course is designed to give students an up-to-date understanding of a wide array of techniques that are used in genetic manipulation 3.This course also focuses on various DNA sequencing and DNA amplification techniques 4.The course also highlights the modern methods of gene and protein probing
6	Course Outcomes	After the successful completion of this course students will be able to: CO1: Identify various molecular tools for genetic engineering; host cells and right kind of enzymes to perform DNA digestion, ligation etc. CO2:Classify different kinds of cloning vectors and their uses. CO3: Analyze the use of Polymerase chain reaction in molecular cloning along and describe various DNA sequencing techniques. CO4: Explain different ways of cloning blunt ended DNA fragments and transfection as well as transformation methods. CO5:Recognize different types of gene libraries and apply different techniques of probing gene libraries
7	Course Description	The 'Genetic Engineering' course outlines the definition, procedure and study of molecular tools in genetic engineering for undergraduate students. This course encompasses the detailed procedure of genetic engineering so that students can become familiar with the Recombinant DNA Technology and its applications

Unit 1	**Genetic engineering tools and methods**	CO1, CO6

A	Restriction Enzymes, DNA ligase, Klenow enzyme, T4 DNA polymerase	
B	Modifying Enzymes, Reverse transcriptase, Other important Nucleases	
C	Cohesive and blunt end ligation; Linkers, Adaptors; Homopolymeric tailing	
Unit 2	**Cloning**	CO2, CO6
A	Cloning vectors: Plasmids; PUC19 and Bluescript vectors	
B	Bacteriophages; M13 mp vectors, Phagemids; Lambda vectors; Insertion and Replacement vectors; Cosmids; Artificial chromosome vectors (YACs; BACs); Animal Virus derived vectors-SV-40 & retroviral vectors	
C	Cloning methodology and selection: Insertion of foreign DNA into vectors; Transformation; Selection, Construction of libraries, cDNA and genomic libraries	
Unit 3	***In vitro* DNA Amplification**	CO3, CO6
A	Nucleic acid extraction	
B	PCR,Types of PCR – multiplex, nested, reverse transcriptase, real time PCR	
C	Labeling of DNA: Nick translation, Random priming, Radioactive and non-radioactive probes, Hybridization techniques: Southern and Colony hybridization	
Unit 4	**Expression**	CO4, CO6
A	Expression vectors: His-tag and GST-tag based vectors	
B	Plant based vectors, Ti plasmid based Co-integrated and binary vectors; Yeast vectors, Shuttle vectors, Expression cloning	
C	Methods gene delivery, Screening and analysis of gene expression and Diagnosis of gene expression	
Unit 5	**Application**	CO5, CO6
A	Gene therapy	
B	Mutagenesis	
C	Transgenic organisms	
Unit 6	**Recombinant products**	
	Recombinant products – human growth hormone (insulin somatotropin)	
	vaccines (hepatitis B virus vaccine, FMD vaccine), interferons, tPA	
Unit 7	**Nucleic acid hybridization**	
	Nucleic acid hybridization: Principles and applications, preparation of probes, principles of nucleic acid hybridization, assays and micro-assays	
Unit 8	**Tools for analyzing gene expression**	
	Reporter genes, Analysis of gene regulation, purification & detection tags, ,	
	Analysis at the level of gene transcription – Northern blot, in situ hybridization, RNAse protection assay, RT-PCR	
	Analysis at the level of translation- Western blot, in situ hybridization, ELISA, protein gel electrophoresis	

	Mode of examination	Theory	

	Weightage Distribution	CA	MTE	ETE	
		30%	20%	50%	
	Textbook/s*	**Genomes 3.** Brown TA. Garland Science Publishing @ 2007. ISBN 08153-41385.			
	Other References	1. **Molecular Biotechnology. Principles and Applications.** 3rd Edition. Glick BR and Pasternak JJ. ASM Press @2003. ISBN 1-55581-224-4. 2. **Gene cloning and DNA Analysis- An Introduction.** 6th Edition. Wiley-Blackwell. Brown TA @2010.			

CO-POmapping

Outcomeno.→	1	2	3	4	5	6	7	8	9
Syllabustopic↓									
Unit1									
A	X								X
B	X								X
C	X								X
Unit2									
A		X							X
B		X							X
C		X							X
Unit3									
A			X						X
B			X						X
C			X						X
Unit4									
A				X					X
B				X					X
C				X					X
Unit5									
A					X				X
B					X				X
C					X				X
Unit6									
A						X			X
B						X			X
C						X			X
Unit7									
A							X		X
B							X		X
C							X		X
Unit8									
A								X	X
B								X	X
C								X	X

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO2	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO3	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO4	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO5	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO6	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO7	**3**	**2**	**3**	**1**	**2**	**3**	**2**
CO8	**3**	**2**	**3**	**1**	**2**	**3**	**2**

BSB202: Metabolic Pathways

L T P: 4-0-0 **Credit: 4**

School: SBSR		**Batch: 2019-2022**
Program: B.Sc. (H)		**Current Academic Year: 2020-21**
Branch: Microbiology		**Semester: 04**
1	Course Code	**BSB202**
2	Course Title	**Metabolic Pathways**
3	Credits	4
4	Contact Hours (L-T-P)	4-0-0
	Course Status	Compulsory
5	Course Objective	1.Carbohydrate Metabolism 2.Lipid metabolism 3.Amino Acid Metabolism 4.Electron Transport Chain 5. Nucleotide Metabolism
6	Course Outcomes	After studying this course, students will be able to CO1: Evaluate metabolism of carbohydrates by different pathways CO2:Interpret the metabolism of different types of lipids CO3: Determine and differentiate between gluconeogenic and ketogenic amino acids CO4: Analyze and learn the electron transport chain CO5: Differentiate between de novo and salvage pathways for biosynthesis of purines and pyrimidines
7	Course Description	This course contains various metabolic pathways inside living cells such as metabolism of carbohydrates, lipids, nucleic acids and also carbon dioxide fixation. After studying course, students will be able to learn various metabolic processes going inside the body of living cells.

Outline syllabus		CO Mapping
Unit 1		**CO1,CO6**
A	Glycolysis	CO1
B	Glycogenolysis, Kreb's cycle and net energy yield	CO1
C	Pentose Phosphate pathway and its clinical significance	CO1
Unit 2		**CO2,CO6**

A	Beta oxidation of fatty acids and energy yield	CO2
B	Cholesterol synthesis	CO2
C	Synthesis of fatty acids	CO2
Unit 3		**CO3,CO6**
A	Introduction to gluconeogenic and ketogenic amino acids	CO3
B	Degradation of amino acids	CO3
C	Synthesisof amino acids, Urea Cycle	CO3
Unit 4		**CO4,CO6**
A	ATP synthase and proton transfer during electron transfer	CO4
B	Coupling of electron transport to oxidative phosphorylation	CO4
C	Inhibitors of electron transport	CO4
Unit 5		**CO5,CO6**
A	Biosynthesis of purines	CO5
B	Biosynthesis of pyrimidines	CO5
C	Structure of DNA and RNA	CO5
Unit 6		
A	Nature of enzymes – kinetics, reaction mechanism of chymotrypsin and lysozyme	
B	purification and physico – chemical characterization, regulation of enzyme activity	
Unit 7		
A	Metabolic basis of nutrition, metabolic basis of specialized tissue function, metabolic disorders, metabolic basis of diagnostics, metabolism and adaption with one example	
Unit 8		
A	regulation of metabolism at molecular	
B	cellular and organismic levels	
C	enzymes and receptors as drug targets.	

	Mode of examination	Theory			
	Weightage Distribution	CA	MTE	ETE	
		30%	20%	50%	
	Textbook/s*	Nelson D.L., Cox M. M., “Principles of Biochemistry” W. H. Freeman, 2012.			
	Other References	Stryer L., “Biochemistry”, W. H. Freeman, 2010. Jain JL., “Principles of Biochemistry”, S. Chand Publications.			

CO-POmapping

Outcomeno.→	1	2	3	4	5	6	7	8	9
Syllabustopic↓									
Unit1									
A	X								X
B	X								X
C	X								X
Unit2									
A		X							X
B		X							X
C		X							X
Unit3									
A			X						X
B			X						X

C			X						X
Unit4									
A				X					X
B				X					X
C				X					X
Unit5									
A					X				X
B					X				X
C					X				X
Unit6									
A						X			X
B						X			X
C						X			X
Unit7									
A							X		X
B							X		X
C							X		X
Unit8									
A								X	X
B								X	X
C								X	X

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO2	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO3	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO4	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO5	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO6	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO7	**3**	**2**	**3**	**1**	**2**	**3**	**2**
CO8	**3**	**2**	**3**	**1**	**2**	**3**	**2**

BSB206: Enzyme Technology

L T P: 4-0-0 **Credit: 4**

School: SBSR		**Batch : 2019-2022**
Program: B.Sc. (H)		**Current Academic Year: 2020-21**
Branch: Microbiology		**Semester: 04**
1	Course Code	**BSB206**
2	Course Title	**Enzyme Technology**
3	Credits	4
4	Contact Hrs. (L-T-P)	4-0-0
	Course Status	Compulsory
5	Course Objective	1.Introduction to Enzymes, their classification and nomenclature 2.Factors affecting enzymatic catalysis 3. Enzyme substrate kinetics 4.Isolation, purification and Immobilization of Enzymes 5. Applications of enzymes in various industries
6	Course Outcomes	After studying this course, students will be able to CO1: Get an overview on enzymes, their nomenclature and factors affecting enzyme activity CO2: Understand the factors affecting rate of biochemical reactions, lock and key as well as induced fit hypothesis CO3: Learn kinetics of enzyme catalysis as well as inhibition reactions CO4: Paraphrase the isolation, purification and immobilization of enzymes CO5 : Implement use of enzymes in leather, dairy, pharmaceutical, food processing and various other industries for human welfare
7	Course Description	The course comprises of the study of enzymes, their nomenclature, classification etc. It comprises of the Fischer's Lock and key as well as Koshland's Induced fit theory of enzyme substrate reaction, enzyme kinetics and applications of enzymes in various industrial sectors.

	Properties of Enzymes	CO1,6
	Classification of enzymes, Structural conformations of enzyme proteins	CO1,6
	Enzymes as biocatalysts, Catalytic power, Activation energy	CO1,6
	Substrate specificity, Mechanisms of enzyme action, Ribozymes and abzymes	CO1,6
	Enzyme Kinetics	CO2,6
	Factors affecting rates of enzymatic reactions (pH, temperature, substrate	CO2,6

	concentration, enzyme concentration and reaction time)	
	Overview of Michaelis-Menten equation and its transformation, Lineweaver-Burke plot	CO2,6
	Evaluation of kinetic parameters (K_M, V_{max})	CO2,6
	Enzyme Inhibition	CO3,6
	Irreversible and reversible inhibition	CO3,6
	Competitive, non-competitive and un-competitive inhibition	CO3,6
	Enzyme inhibition kinetic studies, Determination of k_{cat}.	CO3,6
	Regulation of Enzyme Activity	CO4,6
	Allosterism, Kinetic analysis of allosteric enzymes	CO4,6
	Covalent modification, Feed-back inhibition, Membrane bound enzymes	CO4,6
	Isoenzymes and marker enzymes, Constitutive and inducible enzymes	CO4,6
	Applications of Microbial Enzymes	CO5,6
	Microbial enzymes in textile, leather, wood industries and detergents	CO5,6
	Enzymes in clinical diagnostics and Enzyme sensors for clinical processes and environmental analyses	CO5,6
	Engineered enzymes, Enzymes as therapeutic agents	CO5,6
	Coenzymes	
	Coenzymes - prosthetic group, classification - vitamin and nonvitamin coenzymes, thiamine pyrophosphate - mechanism of oxidative and nonoxidative decarboxylation, transketolase reaction,	
	FMN and FAD - flavoprotein enzymes, mechanism of oxidation and reduction of: flavin enzymes, NAD and NADP role in enzyme catalysis	
	Enzyme technology	
	Industrial uses of enzymes - sources of industrial enzymes, thermophilic enzymes, amylases, glucose isomerases, cellulose degrading enzymes, lipases	
	proteolytic enzymes in meat and leather industry, detergents and cheese production	
	Clinical enzymology	
	Clinical enzymology - Enzymes as thrombolytic agents, antiinflammatory agents, digestive aids. Therapeutic use of asparginase, streptokinase. Diagnostic enzymes. Immobilization of enzymes and their applications. Abzymes	

n	Theory		
	CA	MTE	ETE
n	30%	20%	50%
*	Palmer T., Bonner P. L., *Enzymes: Biochemistry,Biotechnology, Clinical Chemistry*, Woodhead Publishing (2007)		
rences	LubertStryer: Biochemistry, WH Freeman, USA (2002)		

CO-POmapping

Outcomeno.→	1	2	3	4	5	6	7	8	9
Syllabustopic↓									
Unit1									
A	X								X

B	X								X
C	X								X
Unit2									
A		X							X
B		X							X
C		X							X
Unit3									
A			X						X
B			X						X
C			X						X
Unit4									
A				X					X
B				X					X
C				X					X
Unit5									
A					X				X
B					X				X
C					X				X
Unit6									
A						X			X
B						X			X
C						X			X
Unit7									
A							X		X
B							X		X
C							X		X
Unit8									
A								X	X
B								X	X
C								X	X

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO2	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO3	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO4	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO5	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO6	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO7	**3**	**2**	**3**	**1**	**2**	**3**	**2**
CO8	**3**	**2**	**3**	**1**	**2**	**3**	**2**

BSB207: Immunology

L T P: 4-0-0 **Credit: 4**

School: SBSR		**Batch: 2019-2022**
Program: B.Sc. (H)		**Current Academic Year: 2020-21**
Branch: Microbiology		**Semester: 04**
1	Course Code	**BSB207**
2	Course Title	**Immunology**
3	Credits	4
4	Contact Hours (L-T-P)	4-0-0
	Course Status	Compulsory
5	Course Objective	1. Understand the concepts of immune system, immunity, immune responses, cells and organs of immune system 2. Describe about antigens, antibodies and their types & properties, qualitative and quantitative analysis of antigens or antibodies for diagnostic purposes, role of molecules like MHC and cytokines in generation of immune response 3. Explore immunology as a basic toll for medical applications
6	Course Outcomes	CO1: Understand immune system, immunity and immune response. CO2: Describe cells and organs of immune system. CO3: Illustrate about antigens, antibodies and their types & properties. CO4: Demonstrate the qualitative and quantitative analysis of antigens or antibodies for diagnostic purposes. CO5: Identify the role of molecules like MHC and cytokines in generation of immune response. CO6: Explore immunology as a basic tool for medical applications.
7	Course Description	This course will cover the major topics in Immunology, includingimmune system, lines of defense, immunity, immune response, cells and organs of immune system, "antigens, antibodies and their types & properties", qualitative and quantitative analysis of antigens or antibodies for diagnostic purposes, "role of molecules like MHC and cytokines in generation of immune response".

Outline syllabus		CO Mapping
Unit 1	**Immune responses**	CO1, CO6
A	Innate and acquired immunity, humoral and cell mediated immune response	
B	Lines of defense and various barriers	

C	Clonal nature of immune response, Primary and secondary immune response			
Unit 2	**Cells and organs of Immune system**	CO2, CO6		
A	Primary and secondary lymphoid organs, their structure and function			
B	Cells of immune system; hematopoiesis and differentiation			
C	Structure and role of B and T lymphocytes, NK cells, macrophages, Dendritic cells, mast cells, eosinophil's, basophils and neutrophils			
Unit 3	**Antigen and Antibody**	CO3, CO6		
A	Antigen and Immunogen, antigenicity vs immunogenicity, properties of antigens			
B	Antibody molecule, types and structure			
C	Role in immune response, monoclonal antibody and hybridoma technology			
Unit 4	**Antigen Antibody Interaction**	CO4, CO6		
A	Antigen antibody interaction: Immunodiffusion (double and radial)			
B	RIA & ELISA			
C	Immunoelectrophoresis			
Unit 5	**MHC and Cytokines**	CO5, CO6		
A	MHC molecule and its types, structure and their function			
B	Cytokines and their role in immune response			
C	Overview of hypersensitivity and autoimmunity			
Unit 6	**Effector mechanism & regulation of immune response**			
	Signaling through immune system receptors- antigen receptor structure and signaling pathways, other signaling pathways that contribute to lymphocyte behavior			
Unit 7	**Immunity in health and disease**			
	introduction to infectious disease, innate immunity to infection, adaptive immunity to infection, evasion of the immune response by pathogens			
	immunodeficiency diseases- inherited immunodeficiency diseases, acquired immune deficiency syndrome			
Unit 8	**Autoimmunity**			
	responses to self antigens, transplant rejection- responses to alloantigens; manipulation of immune responses,			
	vaccines; evolution of immune system- evolution of innate immune system, evolution of adaptive immune system			
	Mode of examination	Theory		
	Weightage Distribution	CA	MTE	ETE
		30%	20%	50%
	Textbook/s*	Kuby Immunology,7th Edition-R.A. Goldsby, Thomas		
	Other References	1. Immunology-A short course,4th Edition-Eli Benjamini,		

		Richard Coico, Geoffrey Sunshine, (Wiley-Liss). 2. Fundamentals of Immunology, William paul 3. Immunology, By Roitt and others.

CO-PO mapping

Outcome no.→	1	2	3	4	5	6	7	8	9
Syllabus topic↓									
Unit1									
A	X								X
B	X								X
C	X								X
Unit2									
A		X							X
B		X							X
C		X							X
Unit3									
A			X						X
B			X						X
C			X						X
Unit4									
A				X					X
B				X					X
C				X					X
Unit5									
A					X				X
B					X				X
C					X				X
Unit6									
A						X			X
B						X			X
C						X			X
Unit7									
A							X		X
B							X		X
C							X		X
Unit8									
A								X	X
B								X	X
C								X	X

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	1	1	3	2
CO2	3	2	3	1	1	3	2
CO3	3	2	3	1	1	3	2
CO4	3	2	3	1	1	3	2
CO5	3	2	3	1	1	3	2
CO6	3	2	3	1	1	3	2
CO7	3	2	3	1	2	3	2
CO8	3	2	3	1	2	3	2

BSB310: Industrial Biotechnology

L T P: 4-0-0 **Credit: 4**

School: SBSR		**Batch : 2018-21**
Program: BSc		**Current Academic Year: 2020-21**
Branch: Microbiology		**Semester: 5**
1	Course Code	BSB310
2	Course Title	Industrial Biotechnology
3	Credits	4
4	Contact Hours (L-T-P)	4-0-0
	Course Status	Compulsory
5	Course Objective	1. To introduce the students with industrial biotechnology and its application. 2. To develop the knowledge and techniques of production of compounds at indu level. 3. To enable students about process economics and developing cost effective processes 4. To create awareness about fermentation and industrial application microbes.
6	Course Outcomes	After successfully completion of this course students will be able to: CO1: Learn the basics of industrial biotechnology and unit operations used in bi industries. CO2: Apply microbes for the production of industrially important enzymes. CO3: Learn the basics of sustainable processing for biobased products to further under their impact on global sustainability. CO4: Gain knowledge about basics of biosensors and commercial biosensors. CO5: Develop new approaches to pollution prevention, resource conservation, and reduction during bioprocessing. CO6: Comprehend the basic concept of industrial biotechnology and the requirements f application.
7	Course Description	Industrial biotechnology includes modern application of biotechnology for sustai processing and production of chemical products, materials and fuels. Biotechnolo processing uses enzymes and microorganisms to produce products that are useful to a b range of industrial sectors, including chemical and pharmaceutical, human and animal nutr pulp and paper, textiles, energy, materials and polymers, using renewable raw materials.

Outline syllabus		CO Mapping
Unit 1	**Introduction to Industrial Biotechnology**	**CO1,CO6**
A	Units and dimensions	CO1
B	Unit operations involved in Industrial Biotechnology	CO1
C	Products and market economics relating to industrial biotechnology	CO1
Unit 2	**Production of commercially important enzymes**	**CO2,CO6**
A	Cellulases, Amylase, Lipase, Proteases, Lysozyme	CO2
B	Enzymes for the food, pharmaceutical and detergent industries	CO2
C	Biotechnological advances in enzyme production	CO2
Unit 3	**Biotransformation**	**CO3,CO6**
A	Transformation – steroids, alkaloids, and polysaccharides	CO3
B	Recent advances in biotransformation (Indigo, Xanthan, Malanins)	CO3
C	Natural biopreservatives (nisin)	CO3
Unit 4	**Biosensors**	**CO4,CO6**
A	Types of Biosensors	CO4
B	Biomedical Sensors	CO4
C	Commercial examples of Biosensors	CO4
Unit 5	**Industrial Bio-waste management**	**CO5,CO6**
A	Types of industrial waste	CO5
B	Techniques of waste treatment	CO5
C	Value addition to industrial waste	CO5
Unit 6	**Metabolic pathways**	
	Isolation, selection, improvement and maintenance of industrial important strain	
	Metabolic pathways and metabolic control mechanisms; primary metabolites (alcohols, vitamins, enzymes and organic acids	
	secondary metabolites (antibiotics and toxins); substrates for industrial fermentation	
Unit 7	**Continuous culture and scale up**	
	Continuous culture system, productivity, product formation, power requirement oxygen transfer kinetics,	
	foam and antifoam-instrument control, physical and chemical environment sensors.	
Unit 8	**Downstream processing**	
	Downstream processing objectives and criteria, foam separation Precipitation methods filtration devices industrial scale centrifugation and cell disruption methods.	
	liquid -liquid extraction solvent I recovery chromatography. Two phase aqueous extraction, super critical fluid extraction, ultrafiltration drying devices crystallization and whole broth processing	

Mode of examination	Theory		
Weightage Distribution	CA	MTE	ETE
	30%	20%	50%
Text book/s*	1. Michael L. Shuler and FikretKargi (2009, Second edition) Bioprocess Engineering-Basic concepts.		

	Pearson Prentice Hall 2. Pauline M. Doran (2010) Bioprocess Engg. Principles. Elsevier, California.
Other References	1. P. F. Stanbury, S. J. Hall and A. Whitaker, Principles of Fermentation Technology, 2nd Edn., Elsevier, Science & Technology Books, 2005. 2. B.D.Singh (2009, Revised edition) Biotechnology- Expanding Horizons. Kalyani publishers, Ludhiana-141008

CO-POmapping

Outcomeno.→	1	2	3	4	5	6	7	8	9
Syllabustopic↓									
Unit1									
A	X								X
B	X								X
C	X								X
Unit2									
A		X							X
B		X							X
C		X							X
Unit3									
A			X						X
B			X						X
C			X						X
Unit4									
A				X					X
B				X					X
C				X					X
Unit5									
A					X				X
B					X				X
C					X				X
Unit6									
A						X			X
B						X			X
C						X			X
Unit7									
A							X		X
B							X		X
C							X		X
Unit8									
A								X	X
B								X	X
C								X	X

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO2	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO3	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO4	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO5	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO6	**3**	**2**	**3**	**1**	**1**	**3**	**2**
CO7	**3**	**2**	**3**	**1**	**2**	**3**	**2**
CO8	**3**	**2**	**3**	**1**	**2**	**3**	**2**

BSM301: VIROLOGY

LTP: 4-0-0 **Credit – 04**

School : SBSR		**Batch : 2018-21**
Program: B.Sc		**Current Academic Year: 2020-21**
Branch: Microbiology		**Semester: 5**
1	Course Code	**BSM301**
2	Course Title	**Virology**
3	Credits	4
4	Contact Hours (L-T-P)	4-0-0
5	Course Status	
6	Course Objective	This course provide the deep insight of viruses and their basic biology. In addition, the classification, the replication strategies and importance of viruses will be discussed
7	Course Outcomes	After successfully completion of this course students will be able to: CO1 Identify the general characteristics of viruses CO2 Understand the taxonomy of the viruses CO3 Understand the multiplication and replication strategies of viruses CO4 Understand the mode of transmission of viruses CO5 To comprehend the virus's importance including their medical importance
8	Course Description	

Outline syllabus		CO Mapping
Unit 1	**Introduction to Virology**	**CO1,CO6**
A	Discovery of viruses	CO1
B	General properties of viruses; Morphology and ultra structure of viruses;Viroids and prions	CO1
C	Isolation, purification and cultivation of viruses	CO1
Unit 2	**Viral Taxonomy**	**CO1 CO2 CO6**
A	**Di**versity of viruses; Salient features of viral genomes	**CO1 CO2**
B	Classification of viruses infecting microbes, plants and animals	**CO1 CO2**
C	nomenclature of viruses infecting microbes, plants and animals	**CO1 CO2**

Unit 3	**Multiplication and Replication Strategies**	**CO1 CO3CO6**
A	Replication strategies of viruses as per Baltimore classification	**CO1 CO3**
B	Assembly, maturation and release of virions;	**CO1 CO3**
C	Concept of early and late proteins, one step multiplication curve, lytic and lysogenic phages (lambda and P1 phage)	**CO1 CO3**
Unit 4	**Transmission**	**CO1 CO4 CO6**
A	**M**ode of transmission in plant and animals	**CO1 CO4**
B	Cell to cell transmission	**CO1 CO4**
C	Viremia; Persistent and non-persistent mode of transmission;	**CO1 CO4**
Unit 5	**Importance of Viruses**	**CO1 CO5 CO6**
A	Concepts of oncogenes; DNA and RNA oncogenic viruses	**CO1 CO5**
B	Prevention and control of viral diseases; Antiviral compounds, interferons and viral vaccines;	**CO1 CO5**
C	Application of viral vectors in cloning and expression.	**CO1 CO5**
Unit 6	**Plant virus**	
	Plant viruses- Classification and nomenclature of plant viruses; Disease symptoms -histology, physiology and cytology of plants; common viral disease of paddy, tomato and sugarcane	
	Type species of plant viruses (e.g. TMV, Cauliflower mosaic virus and potato virus X), transmission of plant viruses and their preservation	
	Diagnostic techniques (serological methods, histochemical tests and fluorescent microscopy)	
Unit 7	**Animal virus**	
A	Animal viruses – classification and nomenclature of animal and human viruses; epidemiology, life cycle, pathogenicity, diagnosis, prevention and treatment of virus	
B	RNA viruses Picornaviruses, Orthomixoviruses, Paramyxoviruses, Arthropod-borne viruses, Rhabdoviruses, Rotaviruses, HIV and other oncogenic viruses;	
C	viruses DNA viruses – Pox viruses, Herpesviruses, Adenoviruses, Hepatitis viruses; Viral vaccines (conventional)	
Unit 8	**General method of diagnosis and serology**	
A	Cultivation of viruses in animal inoculation, embryonated eggs, cell cultures and cell lines;	
B	Serological methods – haemagglutination,	

	haemagglutination inhibition, complement fixation,	
C	immunofluorescent method, RIA, ELISA etc;	

	Mode of examination	Theory / practical			Theory
	Weightage Distribution	CA	MTE	ETE	
		30 %	20 %	50 %	
	Text book/s*	Dimmock N.J., Easton A.L., and Leppard K.N., *Introduction to Modern Virology, 6th Edition.* Wiley-Blackwell (2007).			
	Other References	Carter J. and Saunders V., *Virology: Principles and Applications*. Wiley (2007). Acheson N.H., *Fundamentals of Molecular Virology, 2nd Edition.* Wiley (2011			

CO-POmapping

Outcomeno.→	1	2	3	4	5	6	7	8	9
Syllabustopic↓									
Unit1									
A	X								X
B	X								X
C	X								X
Unit2									
A		X							X
B		X							X
C		X							X
Unit3									
A			X						X
B			X						X
C			X						X
Unit4									
A				X					X
B				X					X
C				X					X
Unit5									
A					X				X
B					X				X
C					X				X
Unit6									
A						X			X
B						X			X
C						X			X
Unit7									
A							X		X
B							X		X
C							X		X
Unit8									
A								X	X
B								X	X

C								X	X

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	1	1	3	2
CO2	3	2	3	1	1	3	2
CO3	3	2	3	1	1	3	2
CO4	3	2	3	1	1	3	2
CO5	3	2	3	1	1	3	2
CO6	3	2	3	1	1	3	2
CO7	3	2	3	1	2	3	2
CO8	3	2	3	1	2	3	2

Programme/Class: Diploma	**Year:**	**Semester:**
Subject:		
CourseCode:	**Course Title:** Environmental Biotechnology	
Courseoutcomes: •		
Credits:4	**Core:**Compulsory	
Max.Marks:	**Min. Passing Marks :**as per rules	
TotalNo.ofLectures-Tutorials-Practical(inhoursperweek):**L-T-P:**4-0-0		

Unit	**Topic**	**Total No. ofLectures(60)**
I	MICROBIAL ENVIRONMENT Microbiology of Water -Importance of water; Types of Water; Water born diseases; Microbiology of air- Airborne microorganisms	**7**

II	Soil Microbiology- Layers of Soil; Classification; Scope and Importance of Soil Microbiology; Microbes and Biogeochemical cycles; Role of microbes in biogeochemical cycles - Carbon cycle; Sulphur cycle; Nitrogen cycle and Phosphorus cycle.	**7**
III	EUTROPHICATION, AND ITS MANAGEMENT Eutrophication; Microbial changes induced by organic and inorganic pollutants; role of phosphorus and nitrogen in eutrophication; process and control of eutrophication.	
IV	MICROORGANISMS IN EXTREME ENVIRONMENTS Acidophilic; alkalophilic; thermophilic; barophilic and osmophilic; microorganisms- mechanisms of adaptation; Halophiles-membrane variation;Applications of thermophiles and extrempohiles.	**8**
V	MICROBIAL TREATMENT OF WASTE WATER Potability of water - Microbial assessment of water quality; Test of BOD and COD for water analysis. Conventional treatment process; Primary- Sedimentation or settling Principles; Biological waste water treatment-Aerobic suspended-growth; Aerobic attached-growth (TF, RBC, PBR);Anaerobic suspended growth; Anaerobic attached growth;	**6**
VI	Advanced tertiary process:-Solids removal; Biological nitrogen removal Biological phosphorus removal; Disinfection	
VII	BIOREMEDIATION Introduction of Bioremediation;advantages and applications; Types of bioremediation ;Natural (attenuation) ;Ex-situ and In-situ ;Bioaugmentation and biostimulation ;Solid phase and slurry phase bioremediation; Biological Filtration Processes for Decontamination of Air Stream; Biofiltration;Biotrickling Filtration;Bioscrubbers; Use of microbes for Heavy metal detoxification.	**8**
VIII	BIODEGRADATION Aerobic vs. anaerobic Degradation; Microbial basis of Biodegradation; Biodegradation of Xenobiotics; Microbial degradation of pesticides	**8**

SuggestedReadings:

1. Microbiology, M. J. Pelczer ,E.C.S Chan (1993), McGraw Hill Education Private limited , New Delhi.
2. Environmental Microbiology, S.K.Agarwal (2009), APH Publishing corporation, New Delhi
3. Introduction to Environmental biotechnology, A.K.Chatterji (2011), PHI Learning private limited, New Delhi.
4. Environmental Microbiology R.M Maier, I.L. Pepper and C.P.Gerba, Academic Press. (2000).

CO-POmapping

Outcomeno.→	1	2	3	4	5	6	7	8	9
Syllabustopic↓									
Unit1									
A	X								X
B	X								X
C	X								X
Unit2									
A		X							X
B		X							X
C		X							X
Unit3									
A			X						X
B			X						X
C			X						X
Unit4									
A				X					X
B				X					X
C				X					X
Unit5									
A					X				X
B					X				X
C					X				X
Unit6									
A						X			X
B						X			X
C						X			X

Unit7									
A							X		X
B							X		X
C							X		X
Unit8									
A								X	X
B								X	X
C								X	X

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	1	1	3	2
CO2	3	2	3	1	1	3	2
CO3	3	2	3	1	1	3	2
CO4	3	2	3	1	1	3	2
CO5	3	2	3	1	1	3	2
CO6	3	2	3	1	1	3	2
CO7	3	2	3	1	2	3	2
CO8	3	2	3	1	2	3	2

Programme/Class: Diploma	**Year:**	**Semester:**
Subject:		
Course Code:	**Course Title:** Food and dairy biotechnology	

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

-

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

TotalNo.of Lectures-Tutorials-Practical(in hours per week):**L-T-P:**4-0-0

Unit	**Topic**	**Total No. of Lectures(60)**
I	Definition, scope and historical development of biotechnology, achievement and future application: structure of DNA and RNA; DNA replication, protein synthesis, genetic code, mutations: Vectors, cloning strategies in bacteria and animals, DNA technology.	**7**
II	Protoplast fusion & Tissue culture in dairy cultures. Application of biotechnology in food and dairy industry, dairy effluents. Genetic manipulation of dairy starters for improved attributes of commercial value. Dairy enzymes and whole cell immobilization. Ethical issues related to use of genetically modified foods.	**7**
III	Genetic recombination mechanisms and technique used for improvement in microbial strains. Applications of genetical control mechanism in industrial fermentation process, (Induction, manipulation and recombination). RecombinantDNA technology (plasmids and cloning):	

IV	Cell and tissue culture. Continuous cultures. Secondary metabolites synthesis. Expression of foreign genes. Promoter (Enzyme). Biomass production by using various micro organisms. Application of Biotechnology in food (Food industries), pharmaceuticals and agriculture. Biogas plant.	**8**
V	Microbes of food and fermented food- Curd, wheat and rice flour, Meat and fish, Poultry and eggs, Breads and bakery products, Grains Microbiological contamination of foods- indicator organisms, cultural techniques, direct methods, immunological methods etc..	**6**
VI	Module Microbes involved in food spoilage- Spoilage of Canned foods Meat and dairy products. Conditions of food spoilage- pH, physical structure, chemical composition, oxygen and temperature Chemistry of food spoilage-microbial toxins and food poisoning Food borne diseases and its prevention	
VII	Food Preservation- methods of food preservation, Physical & Chemical Methods, Osmotic pressure – preserving foods in sugar and salt, chemical preservatives, Radiation as a preservation methods	**8**
VII	Microbes of Dairy industry- Dairy products Microbes in fermented food production Industrial production of antibiotics (penicillin & streptomycin) and organic acids (acetic acid & Citric acids) Microorganisms as food – fermented food, microalgae- Single cell protein, Edible amshrooms.	**8**

Suggested Readings:

5. Kumar HD. (1990). *Introductory Phycology*. 2nd edition. Affiliated East Western Press.
6. Kumar HD. (1995). *The Text Book on Algae*. 4th edition. Affiliated East Western Press
7. Alexopoulos CJ, Mims CW and Blackwell M. (1996). *Introductory Mycology*. 4th edition. John Wiley and Sons, Inc

CO-POmapping

Outcomeno.→	1	2	3	4	5	6	7	8	9
Syllabustopic↓									
Unit1									
A	X								X
B	X								X
C	X								X
Unit2									
A		X							X
B		X							X
C		X							X
Unit3									
A			X						X
B			X						X
C			X						X
Unit4									
A				X					X
B				X					X
C				X					X
Unit5									
A					X				X
B					X				X
C					X				X
Unit6									
A						X			X
B						X			X
C						X			X
Unit7									
A							X		X
B							X		X
C							X		X
Unit8									
A								X	X
B								X	X
C								X	X

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	1	1	3	2
CO2	3	2	3	1	1	3	2
CO3	3	2	3	1	1	3	2
CO4	3	2	3	1	1	3	2
CO5	3	2	3	1	1	3	2
CO6	3	2	3	1	1	3	2
CO7	3	2	3	1	2	3	2
CO8	3	2	3	1	2	3	2

Microbial Biotechnology

LT P:4-0-0 **Credit:4**

School: SBSR			
Program: M.Sc. (H)			
Branch: Microbiology			
1	Course Code		
2	Course Title	**Microbial Biotechnology**	
3	Credits	4	
4	Contact Hrs. (L-T-P)	4-0-0	
	Course Status	Compulsory	
5	Course Objective	1. Some Potential Sources of Components of Industrial Media 2. Product recovery, Solids (Insolubles) Removal 3. Industrial production of organic acids 4. Role of microorganisms in hydrocarbon degradation	
6	Course Outcomes	After studying this course, students will be able to CO1: Determine Primary and Secondary screening, Production strains, and Production media CO2: Evaluate Filtration; Centrifugation; Coagulation and flocculation CO3: Interpret the production of microbial insecticides, production of Biopolymers, Biofuels CO4: Analyze the role of microorganisms in hydrocarbon degradation CO5: Determine Role of microorganism in Bioleaching and Textile Industry. CO6 : Analyze types of microorganisms found on textile fibres	
7	Course Description	This course contains introductory part of industrial biotechnology which includes various useful microorganisms, their production, different types of fermenters, product recovery processes. After this course study student will able to learn the role of microorganisms in textile industry and marine environment.	
8	Outline syllabus		Lecture hours (60 h)
	Unit 1	**Industrial Media and strains**	**8**
	A	Introduction and history, Isolation and screening, Primary and Secondary screening.	2
	B	Production strains, Production media.	3
	C	Raw Materials Used in Compounding Industrial Media, Growth Factors, Water, Some Potential Sources of Components of Industrial Media.	3
	Unit 2	**Inoculum preparation and strain development**	**8**
	A	Inoculum preparation, strain improvement	2
	B	Introduction to Fermenter	3
	C	Industrial sterilization, cell death kinetics	3
	Unit 3	**Product recovery, Removal of Solids**	**8**
	A	Intracellular and extracellular products, cell disruption	2
	B	Filtration; Centrifugation; Coagulation and flocculation	3
	C	Extraction, Precipitation, Crystallization	3
	Unit 4	**Production of Antibiotics**	**8**

	A	Introduction, classification, β-lactum antibiotics			2
	B	Production, purification and application of penicillin			3
	C	Production, purification and application of cephalosporin			3
	Unit 5	**Production of organic acids**			**7**
	A	Production, biosynthetic pathway of citric acid production			3
	B	Production and application of lactic acid			2
	C	L-glutamic acid			2
	Unit 6	**Microbial biotransformation**			**7**
	A	Introduction, types of microbial biotransformation			3
	B	Transformation of steroids and sterols			2
	C	Transformation of antibiotics and pesticides			2
	Unit 7	**Petroleum Microbiology**			**7**
	A	Types of compounds in petroleum, products of compounds in petroleum			3
	B	Microorganisms in hydrocarbon system			2
	C	Role of microorganisms in hydrocarbon degradation			2
	Unit 8	**Role of microorganism in Bioleaching**			**7**
	A	Definition of Bioleaching			1
	B	Microorganisms involved in various bioleaching process			3
	C	Chemistry of microbial leaching and beneficiation			3
	Mode of examination	**Theory**			
	Weightage Distribution	CA	MTE	ETE	
		30%	20%	50%	
	Textbook/s*	1. Crueger&Crueger Biotechnology: A Text Book of Industrial microbiology 2nd edition 2. Demain, A.L Biology of Industrial Microorganisms			
	Other References	1. Hobbs, B.C. and Rioberts,D 1993 Food Poisoning and Food Hygiene Edward Anold, London. 2. Patel, A.H. Industrial microbiology			

CO-PO mapping

Outcome no.→	1	2	3	4	5	6	7	8	9
Syllabus topic↓									
Unit1									
A	X								X
B	X								X
C	X								X

Unit2									
A		X							X
B		X							X
C		X							X
Unit3									
A			X						X
B			X						X
C			X						X
Unit4									
A				X					X
B				X					X
C				X					X
Unit5									
A					X				X
B					X				X
C					X				X
Unit6									
A						X			X
B						X			X
C						X			X
Unit7									
A							X		X
B							X		X
C							X		X
Unit8									
A								X	X
B								X	X
C								X	X

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	1	1	3	2
CO2	3	2	3	1	1	3	2
CO3	3	2	3	1	1	3	2
CO4	3	2	3	1	1	3	2
CO5	3	2	3	1	1	3	2
CO6	3	2	3	1	1	3	2
CO7	3	2	3	1	2	3	2
CO8	3	2	3	1	2	3	2

Programme/Class: Diploma	**Year:** 1st	**Semester:** 2nd
Subject: ZOOLOGY		
CourseCode: B050301T	**Course Title:** Mycology & Phycology	

Course outcomes:

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

- A detailed and conceptual understanding of physiology and structural concept of fungi.
- A clear understanding of phylogeny and reproduction of fungi
- Understanding of general characteristics of m o l d s
- Learn how host responses to fungal infection-Immunity Antifungal agents.
- A detailed and conceptual understanding of economical importance of fungi.
- A detailed and conceptual understanding of characteristics of algae
- A clear understanding of classification of different algal divisions
- A detailed and conceptual understanding of economical importance of algae.

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

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

Unit	**Topic**	**Total No. of Lectures (60)**
I	**Fungal physiology, structure and symbiosis** o Nutrition, physiology, ecology o Fungal morphology, spores and cell walls o Symbiosis and pathogenesis	**7**
II	**Fungal reproduction & phylogeny** Asexual and sexual reproduction in fungi Classification andgeneral characteristics of different fungal groups – (i) Microsporidia (ii) Chytridiomycota (iii)Zygomycota (iv) Glomeromycota(v) Ascomycota(vi) Basidiomycota	**7**

III	**Slime molds and water molds** General characteristics, reproduction and life cycles of division - **Myxomycota** - **Acrasiomycota** - **Oomycota**	
IV	**Medical mycology-** • Culture methods fungi, Diagnosis, Dimorphism Mycoses (Superficial) (Opportunistic) Systemic) • Host responses to fungal infection-Immunity Antifungal agents	**8**
V	**Economic Importance of Fungi** • Economic importance of fungi with examples in agriculture, environment, industry, medicine, food. • Bioremediation (of wood, paper, textile, leather), • Mycotoxins.	**6**
VI	**Intoduction to algae** o Distribution of algae o Ultra-structure of algal cell o Algal nutrition o Algal reproduction	
VII	**Classification of algae** General characteristics and reproduction of different algal divisions : 1. Chrysophyta 2. Euglenophyta 3. Pyrrhophyta 4. Charophyta 5. Chlorophyta 6. Phaeophyta 7. Rhodophyta	**8**
VII	**Economic importance of algae** • Economic importance of algae with examples in agriculture, environment, industry, medicine, food. • Lichens • Chlorella and Spirulinaare • Role of algae in eco-system	**8**
VIII	•	**8**

SuggestedReadings:

8. Kumar HD. (1990). *Introductory Phycology*. 2nd edition. Affiliated East Western Press.
9. Kumar HD. (1995). *The Text Book on Algae*. 4th edition. Affiliated East Western Press
10. Alexopoulos CJ, Mims CW and Blackwell M. (1996). *Introductory Mycology*. 4th edition. John Wiley and Sons, Inc

CO-POmapping

Outcomeno.→	1	2	3	4	5	6	7	8	9
Syllabustopic↓									
Unit1									
A	X								X
B	X								X
C	X								X
Unit2									
A		X							X
B		X							X
C		X							X
Unit3									
A			X						X
B			X						X
C			X						X
Unit4									
A				X					X
B				X					X
C				X					X
Unit5									
A					X				X
B					X				X
C					X				X
Unit6									
A						X			X
B						X			X
C						X			X
Unit7									
A							X		X
B							X		X
C							X		X
Unit8									
A								X	X
B								X	X
C								X	X

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	1	1	3	2
CO2	3	2	3	1	1	3	2
CO3	3	2	3	1	1	3	2
CO4	3	2	3	1	1	3	2
CO5	3	2	3	1	1	3	2
CO6	3	2	3	1	1	3	2
CO7	3	2	3	1	2	3	2
CO8	3	2	3	1	2	3	2