National College (Autonomous)

(For the students admitted from the Academic Year 2021-2022 onwards)

Syllabus for B.Sc., MICROBIOLOGY

PG & Research Department of Biotechnology & Microbiology

National College (Autonomous)

Tiruchirappalli – 620 001.

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PG & RESEARCH DEPARTMENT OF BIOTECHNOLOGY & MICROBIOLOGY

VISION

Transforming individuals into globally competent professionals with moral and ethical values.

MISSION

As a department, we are committed to

- ✓ Achieve Academic Excellence in Microbiology through innovative teaching and learning processes
- ✓ Prepare the students to be a professionally competent to face the challenges in their work environment
- ✓ Establish world class infrastructure facilities in microbiology
- ✓ Encourage the students for active participation in co-curricular and extracurricular activities
- ✓ Promote inter-disciplinary research among the faculty and the students
- ✓ Motivate the students to acquire entrepreneurial skills to become global leaders
- ✓ Practice ethical standards by the faculty and students
- ✓ Enabling the faculty to improve their knowledge through continuous improvement programmes.

PROGRAM EDUCATIONAL OBJECTIVES

B.Sc., Microbiology program will enable the graduates to

PEO1	Have a successful career in Microbiology and related disciplines.
PEO2	Excel in research career in microbiology and inter-disciplinary fields and actively contribute to science and society.
PEO3	Possess technical and professional competency to address growing demands of society and industrial needs ethically.
PEO4	Demonstrate lifelong independent and reflective skills in their career.
PEO5	Apply research and entrepreneurial skills augmented with a rich set of communication, teamwork and leadership skills to excel in their profession.
PEO6	Show continuous improvement in their professional career and appreciate human values and ethics

PROGRAM OUTCOMES

On completion of B.Sc., Microbiology Program, the students are expected to

No.	Description
PO1	Proficient knowledge in the lead domains of Microbiology
PO2	Enriched written and verbal communication for the dissemination of knowledge and ideas.
PO3	Efficiency to solve complex problems, critically relate, analyse existing situations and proficiency for the selection of appropriate tools/instrument
PO4	Knowledge that imparts leadership and teamwork qualities for applications in various fields of Microbiology and research
PO5	Moral, ethical, public and environmental awareness associated with sustainability issues.
PO6	Multi-cultural competency, self-instrospected attitudes and thirst for life-long learning

B.Sc. MICROBIOLOGY
COURSE STRUCTURE UNDER C.B.C.S.

(Applicable to Candidates admitted from the Academic Year 2021-22 onwards)

Sem	Part	Course	Course Title	Hrs/ Wk	Credit	Exam Hrs.	Marks			Total
							CIA	External		
								W	O	
I	I	-	Tamil – I/ Hindi – I/ Sanskrit – I	6	3	3	25	75	-	100
	II	-	English – I	6	3	3	25	75	-	100
	III	Core Course I U21MB1	General Microbiology	5	5	3	25	75	-	100
		Core Course II U21MB2P	Lab in General Microbiology & Microbial Physiology	3	-	-	-	-	-	-
		Allied Course I U21AMB1	Biochemistry I: Biomolecules	5	4	3	25	75	-	100
		Allied Course II U21AMB2P	Lab in Biochemistry	3	-	-	-	-	-	-
	IV	-	Environmental Studies	2	2	3	25	75	-	100
Total				**30**	**17**					**500**
II	I	-	Tamil – II/Hindi – II/ Sanskrit – II	6	3	3	25	75	-	100
	II	-	English – II	4	2	3	25	75	-	100
		-	Communicative English – 1	2	1	3	25	70	05	100
	III	U21MB2P	Lab in General Microbiology & Microbial Physiology	3	4	3	25	70	05	100
		Core Course III U21MB3	Microbial Physiology	5	5	3	25	75	-	100
		U21AMB2P	Lab in Biochemistry	3	3	3	25	70	05	100
		Allied Course III U21AMB3	Biochemistry II: Intermediary Metabolism	5	4	3	25	75	-	100
	IV	Skilled Based Elective I U21SBE1	Introduction to Bioentrepreneurship Skills	2	2	3	25	75	-	100
Total				**30**	**24**					**800**

III	I	-	Tamil – III/Hindi – III/ Sanskrit – III	6	3	3	25	75	-	100
	II	-	English – III	6	3	3	25	75	-	100
	III	Core Course IV U21MB4	Bacteriology	4	4	3	25	75	-	100
		Core Course V U21MB5P	Lab in Bacteriology & Microbial Genetics and Molecular Biology	3	-	-	-	-	-	-
		Allied Course IV U21AMB4	Bioinstrumentation	4	4	3	25	75	-	100
		Allied Course V U21AMB5P	Lab in Bioinstrumentation and Biostatistics	3	-	-	-	-	-	-
	IV	Skilled Based Elective II U21SBE2/ U21SBE3	Bioentrepreneurship Skills I/II	2	2	3	25	75	-	100
		Skilled Based Elective III U21SBE4P/ U21SBE5P	Lab in Bioentrepreneurship Skills I/II	2	2	3	25	70	05	100
Total				**30**	**18**					**600**
IV	I	-	Tamil – IV/Hindi – IV/ Sanskrit – IV	6	3	3	25	75	-	100
	II	-	English – IV	4	2	3	25	75	-	100
		-	Communicative English – II	2	1	3	25	70	05	100
	III	U21MB5P	Lab in Bacteriology & Microbial Genetics and Molecular Biology	3	4	3	25	70	05	100
		Core Course VI U21MB6	Microbial Genetics and Molecular Biology	4	4	3	25	75	-	100
		U21AMB5P	Lab in Bioinstrumentation and Biostatistics	3	3	3	25	70	05	100
		Allied Course VI U21AMB6	Biostatistics	4	4	3	25	75	-	100
		Non-Major Elective I U21NMBT1	Animal cell culture	2	2	3	25	75	-	100

	IV	-	Value Education	2	2	3	25	75	-	100
Total				**30**	**25**					**900**

V	III	Core Course VII U21MB7	Mycology and Parasitology	5	5	3	25	75	-	100
		Core Course VIII U21MB8	Virology	5	5	3	25	75	-	100
		Core Course IX U21MB9P	Lab for Courses in Semester V	6	4	3	25	70	05	100
		Elective Course I U21MB10E	Immunology	5	5	3	25	75	-	100
		Elective Course II U21MB11E	rDNA Technology	5	4	3	25	75	-	100
	IV	Non-Major Elective II U21NMBT2	Bioprocess Technology	2	2	3	25	75	-	100
		-	Soft Skills	2	2	3	25	75	-	100
Total				**30**	**27**					**700**
VI	III	Core Course X U21MB12	Food, Dairy and Industrial Microbiology	6	6	3	25	75	-	100
		Core Course XI U21MB13	Agricultural and Environmental Microbiology	6	6	3	25	75	-	100
		Core Course XII U21MB14	Diagnostic Microbiology	6	6	3	25	75	-	100
		Core Course XIII U21MB15P	Lab for Courses in Semester VI	6	4	3	25	70	05	100
		Elective Course III U21MB16E	Bioinformatics	5	5	3	25	75	-	100
	V	-	Gender Studies	1	1	3	25	75	-	100
		-	Extension Activities	-	1	-	-	-	-	-
Total				**30**	**29**					**600**
Grand Total				**180**	**140**					**4100**

SEMESTER – I		**CODE – U21MB1**

Core Course I: GENERAL MICROBIOLOGY		
CREDITS - 5		**HOURS - 5**

Objectives

- To understand the basic classification of microbes.
- To understand the basic structure of bacteria.
- To explain the control and isolation of microorganisms.
- To describe microbial identification.

Course Outcomes (CO)

At the completion of the Course, the student would be able to:

Cognitive level	Course outcome	Knowledge Level
CO1	➢ Define basic concepts, classification and general characteristics of organisms	K1
CO2	➢ Explain general characters of different groups of microbes and it's applications	K2
CO3	➢ Apply the different methods of sterilization, culture techniques, staining techniques and types of media	K3
CO4	➢ Distinguish the characteristics of prokaryotic and eukaryotic organisms and types of microscope	K4
CO5	➢ Determine different methods of bacterial identification.	K5
CO6	➢ Discuss about maintenance and preservation methods of microbes.	K6

C1–Remember C2-Understand C3 –Apply

UNIT I

Introduction: Definition, scope and history of microbiology; Classification of microorganisms – general principles and nomenclature – Haeckel's three kingdom concept, Whittaker's five kingdom concept, Carl Woese's Classification, Bergey's manual of systematic bacteriology; Microscopy- Light, Phase contrast, Interference, Fluorescence and Electron microscopy; SEM – TEM - principles - applications and limitations.

UNIT II

Differences between prokaryotic and eukaryotic microorganisms; Structural organization of bacteria – Size, shape and arrangement of bacterial cells; Ultrastructure of a bacterial cell: Cell wall, cell membrane, ribosomes, nucleoid, slime, capsule, flagella, fimbriae, spores, cysts, plasmid, mesosomes and cytoplasmic inclusions.

UNIT III

General characteristics and nature of Eubacteria, Cyanobacteria, Mycoplasmas, Rickettsiae, Chlamydias, Spirochaetes, Actinobacteria, Protozoa, Algae, Fungi and Viruses.

UNIT IV

Archaea Classification (Crenarchaeota, Euryarchaeota, Korarchaeota, Thaumarchaeota, Nanoarchaeota) – origin and evolution – Morphology – Cell wall and flagella – Membranes – archaeal viruses– ecology.

UNIT V

Control of Microorganisms: Sterilization-Principles and methods–physical (moist heat, dry heat, filtration, pasteurization, tyndallization, radiations) and chemical (alcohols, aldehydes, phenols, halogens, hypochlorites and antibiotics). Isolation of microbes- Types of culture media (simple, defined, differential, selective, enriched, enrichment and transport media) with specific examples for each type; Aerobic and Anaerobic culture techniques-Pure culture techniques – Methods of maintenance and preservation of microbes. Principles of staining: Types of staining – simple, differential, negative, acid fast, flagella and spore staining. Methods of bacterial identification – morphological, physiological, biochemical and serological properties.

TEXTBOOKS

1. Wiley JM, Sherwood LM and Woolverton CJ. (2013) Prescott's Microbiology. 11th Edition. McGraw Hill International.
2. Pelczar Jr, M.J. Chan, E.C.S. and Kreig, N.R. (2006). Microbiology, Mc. Graw Hill. Inc, NewYork.
3. Holt, J.S., Kreig, N.R., Sneath, P.H.A and Williams,S.T. Bergey's Manual of Determinative Bacteriology (9th Edition), Williams and Wilkins,Baltimore.

REFERENCE BOOKS

1. Mackie and McCartney. (1989). Practical Medical Microbiology, ChurchillLivingston.
2. Stainer, Ingharam, Wheelis and Painter. 1987. General Microbiology. 5th Edition. Macmillan Education, London.
3. Tortora, G.J., Funke, B.R. and Case, C.L. 2012. Microbiology - An Introduction. 11th Edition. PearsonEducation.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	1	3	3	9
CO2	3	3	3	9	3	9
CO3	9	1	3	3	9	9
CO4	9	3	1	3	3	9
CO5	9	3	3	9	9	9
CO6	3	3	1	3	9	9
Weightage	42	16	12	30	36	54

SEMESTER - I		CODE – U21MB2P
Core Course II: LAB IN GENERAL MICROBIOLOGY AND MICROBIAL PHYSIOLOGY		
CREDITS – 3		HOURS - 6

Lab in General Microbiology and Microbial Physiology
(Group & Individual practical– under STAR College Scheme)

GENERAL MICROBIOLOGY

Cognitive level	Course outcome	Knowledge Level
CO1	Name the general practices in microbiology laboratory	K1
CO2	Demonstrate different parts of microscope and their handling to visualize microbes	K2
CO3	Select various methods of media preparation	K3
CO4	Examine microbes by staining techniques.	K4
CO5	Evaluate pure culture techniques to isolate microbes	K5
CO6	Visualize motility of bacteria	K6

1. Microbiology laboratory: general practices and maintenance.
2. Microscopes – Basic Parts and Handling
3. Sterilization Principles and Techniques
4. Hanging Drop Experiment
5. Staining Techniques: Simple, Gram, Acid Fast, Spore
6. Media preparation: liquid, solid and agar slants, basal, enriched, enrichment, differential and selective
7. Inoculation techniques – pour plate – spread plate –dilution techniques
8. Morphological Identification of Fungi- wet mount KOH, LPCB staining
9. Micrometry

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	1	3	3	9
CO2	3	3	3	9	3	9
CO3	9	9	9	3	9	9
CO4	9	3	3	3	9	9
CO5	9	3	3	9	9	9
CO6	3	3	9	9	9	9
Weightage	42	30	28	36	42	54

SEMESTER - I		CODE – U21AMB1
Allied Course I: BIOCHEMISTRY I- BIOMOLECULES		
CREDITS – 4		HOURS - 5

Objectives:

- To understand the atomic, molecular structures and molecular bonding.
- To understand the occurrence and structure of carbohydrates.
- To correlate the protein functions with their native conformations.
- To differentiate the different classes and forms of lipids.
- To comprehend the basic characteristics of nucleic acids and vitamins.

Course Outcomes:

At the completion of the course, the student would be able to:

Cognitive level	Course outcome	Knowledge Level
CO1	Define basic concepts, definitions and properties of biomolecules	K1
CO2	Classify, compare and cite structural aspects of biomolecules	K2
CO3	Apply structural aspects of biomolecules with functional relevance to proteins, vitamins and nucleic acid.	K3
CO4	Compare, contrast and distinguish proteins, lipids, carbohydrates and nucleic acid	K4
CO5	Summarize sequencing methodologies of proteins and validate	K5
CO6	Prepare buffers, estimation of protein, carbohydrate, compare summarize DNA denaturation and renaturation.	K6

C1 – Remember C2 – Understand C3 – Apply

UNIT I:

Atoms and molecules; Bonding: types; Water: properties; Acids, Bases and Buffers; Chemistry of Carbohydrates: definition and classification, Occurrence and structure of monosaccharides, disaccharides and polysaccharides; Linear and ring forms (Haworth formula) for glucose, fructose. sucrose and lactose; Properties of carbohydrates: Isomerism, mutarotation, oxidation, reduction; functions of carbohydrates.

UNIT II:

Chemistry of amino acids and proteins: definition and classification of amino acids, common properties of amino acids, amphoteric nature, isoelectric point, isoelectric pH and Zwitterion - Reaction with ninhydrin, 1-fluoro-2, 4-dinitro nitrobenzene (FDNB) and SiegFried-s reaction; Proteins: Classification and Properties - Physical properties: salting in and salting out, denaturation, peptide bond ; Structure of protein: primary, secondary, tertiary and quaternary - N-terminal determination – Edmans method and C- terminal determination - Van-Slyke Reaction.

UNIT III:

Chemistry of Lipids: Definition, classification and functions. Occurrence, chemistry and biological functions-simple lipids: tertiary compound lipids (e.g. phospholipids), derived lipids: steroids (e.g. cholesterol); Saturated fatty acids: Butyric, arachidic and stearic acid; Unsaturated fatty acids: Oleic, linoleic and linolenic acid; Physical property: emulsification; Chemical properties-saponification, rancidity; Definition of acid number, saponification number, iodine number and Reichert-Meissl number; Bile acid and bile salt functions.

UNIT IV:

Chemistry of Nucleic acids: Definition, purines and pyrimidine bases, nucleoside, nucleotide and polynucleotide; Double helical model of DNA and its biological functions – Absorbance and effect of temperature; DNA types; Structure of RNA: tRNA, mRNA and rRNA-occurrence, chemistry and its biological functions; Differences between DNA and RNA.

UNIT V:

Vitamins: Definition, classification, water soluble (vitamin B1, B2, B3, B6, B12 and C) and fat-soluble vitamins (A, D, E and K) – occurrence, deficiency diseases, biochemical roles, daily requirements.

TEXTBOOKS

1. Fundamentals of Biochemistry - J.L. Jain, Sunjay Jain, Nitin Jain, S. Chand &Company.
2. Harper's Biochemistry- Rober K. Murray, Daryl K. Grammer, McGraw Hill, Lange Medical Books. 25th edition.

REFERENCE BOOKS

1. Biochemistry – Voet and Voet, 4th Edition, Wiley Publication
2. Biochemistry- Dr. Amit Krishna De, S. Chand & Co., Ltd.
3. Biochemistry – J. M. Berg, J. L. Tymochzo, L. Stryer (7th Edition) W. H. Freeman Publisher.
4. Lehninger Principles of Biochemistry- David L. Nelson, Michael M. Cox, Macmillan Worth Publishers.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	1	1	9	1	3
CO2	9	1	3	9	1	3
CO3	9	1	3	9	1	3
CO4	9	3	9	9	1	9
CO5	9	3	9	9	3	3
CO6	9	9	9	9	3	3
Weightage	54	18	34	54	10	24

SEMESTER-I & II		CODE – U21AMB2P
Allied Course II: LAB IN BIOCHEMISTRY		
CREDITS – 3		HOURS - 6

Lab in Biochemistry
(Group & Individual practical– under STAR College Scheme)

Course Outcomes:

At the completion of the course, the student would be able to:

Cognitive level	Course outcome	Knowledge Level
CO1	Learn lab safety protocols, working principle and basic handling, maintenance of common laboratory equipment	K1
CO2	Understand and apply calculations needed for the preparation of solutions employed in biochemical experiments.	K2
CO3	Gain knowledge and skills needed for the estimation of various biomolecules	K3
CO4	Compare, contrast and distinguish estimation procedure applied for proteins, lipids, carbohydrates and nucleic acid	K4
CO5	Evaluate biomolecular estimation protocols and data applications.	K5
CO6	Design and modify appropriate biochemical estimation protocols.	K6

1. Basic calculations in Biochemistry - Normality, Molarity, Molality percent solutions (v/v, w/v).
2. Calibration of pH meter
3. Preparation of biological buffer - phosphate buffer
4. Extraction of Proteins from biological materials
5. Protein separation methods: -Ammonium sulphate Precipitation
6. SDS PAGE – Group Experiment
7. Estimation of Proteins by Lowry's method
8. Estimation of Proteins by Biuret method
9. Purity check of DNA & RNA by UV Spectrophotometry - A260/280
10. Separation of amino acids by Paper Chromatography
11. Separation of sugars by Paper Chromatography
12. Separation of amino acids by Thin layer chromatography
13. Separation of sugars by Thin layer chromatography

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	9	1	3
CO2	3	1	3	9	1	3
CO3	3	1	3	9	1	9
CO4	9	3	9	9	1	9
CO5	9	3	9	9	3	9
CO6	9	9	9	9	3	9
Weightage	36	18	34	54	10	42

SEMESTER - II		CODE – U21MB3
Core Course III: MICROBIAL PHYSIOLOGY		
CREDITS – 5		HOURS - 5

Objectives:

- To learn the infrastructure of a microbial cell and its function.
- To understand microbial nutrient requirements and classification.
- To learn different phases of microbial growth and its association.
- To learn energy yielding and efficient metabolism.
- It provides different aspects of stress physiology and survival.

Course Outcomes:

On successful completion of the course, students will be able to

Cognitive level	Course outcome	Knowledge Level
CO1	Define microbial cell structure and components, different terminologies associated with nutritional requirements of microorganisms	K1
CO2	Explain about bacterial growth curve and factors influencing it, microbial association and transport of nutrients	K2
CO3	Categorize microbial metabolisms and biosynthetic pathway	K3
CO4	List out microbial associations and Stress physiology	K4
CO5	Asses aerobic, anaerobic respiration process and different fermentation process	K5
CO6	Elaborate the Survival of microbes in extreme environments	K6

C1–Remember C2-Understand C3 -Apply

UNIT I

Microbial cell: Ultra structure of Prokaryotic and Eukaryotic cell. Biosynthesis of peptidoglycan - outer membrane, teichoic acid – Exopolysaccharides; Subcellular structures and cell envelope, S-layer, Capsules, Cell wall, Pili, Fimbriae, Flagella, Cell - inclusions, Endospores, Plasma membrane – Liposomes.

UNIT II

Nutrition and transport: Microbial nutritional requirements– growth factor, nutritional classification of bacteria-Autotrophs, Heterotrophs, Photoautorophs, Chemoautotrophs, Copiotrophs, Oligotrophs, lithotrophs and Autochthonous microbes. Transport: modes of nutritional uptake - passive and facilitated diffusion, active transport, group translocation, sym, anti and uniport- transport of Iron – sporulation.

UNIT III:

Microbial growth: Phases of growth curve – measurement of growth – calculations of growth rate – generation time – synchronous growth – induction of synchronous growth, synchrony index – factors

influencing growth – pH, temperature, substrate and osmotic condition. Microbial association- microbiome, biofilm, bioluminescence, quorum sensing- mechanism – advantages.

UNIT IV

Energy yielding metabolism: Overview of microbial metabolism: biosynthetic pathway specific to microbes, homo and hetero fermentation. aerobic and anaerobic respiration. Energy efficiency in C1 metabolism. Energy from visible radiation.

UNIT V

Stress physiology: Osmotic stress and osmoregulation, stress response-oxidative, pH, acid tolerance, thermal, and heat shock, nutrient and starvation stress, extremophiles. Cell wall composition, spore-cell division, endospore, structure, general properties and dormancy, Survival at extreme environments- thermophilic, alkalophilic, osmophilic and psychrophilic.

TEXTBOOKS

1. Pelczar Jr, M.J. Chan, E.C.S. and Kreig, N.R. (1993). Microbiology, Mc. Graw Hill. Inc, New York.
2. Lansing M. Prescott, John P. Harley and Donald A. Klein. (2003). Microbiology. (5th edition). McGraw-Hill company, Newyork.
3. Stainer, Ingharam, Wheelis and Painter. (1987). General Microbiology. 5thEdition. Macmillan Education, London.

REFERENCE BOOKS

1. Rabert Poole, K. (2007). Advances in Microbial Physiology, Volume 53 Elsevier Science & Technology.
2. Caldwell, D.R. (1995). Microbial Physiology and metabolism, Wm. C. Brown Publishers, USA
3. Moat, A.G., Foster, J.W. and Spector, M. P. (2002). Microbial Physiology (4th Edition). John Wiley & Sons, New York.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	3	9
CO2	9	1	3	3	3	3
CO3	9	3	3	1	9	9
CO4	3	3	1	3	3	9
CO5	9	3	3	3	3	3
CO6	9	3	3	3	9	9
Weightage	48	16	21	22	30	42

SEMESTER - II		CODE - U21AMB3
Allied Course II: BIOCHEMISTRY II- INTERMEDIARY METABOLISM		
CREDITS - 4		HOURS - 5

Objectives:

- To interpret the metabolic pathways of carbohydrates and their significance in energy production.
- To understand the anabolic and catabolic mechanisms relative to proteins.
- To differentiate the biological significance of nucleic acids, co-factors and co-enzymes.

Course Outcomes:

At the completion of the course, the student would be able to:

Cognitive level	Course outcome	Knowledge Level
CO1	Define metabolic concepts and pathways	K1
CO2	List and describe various metabolic pathways	K2
CO3	Apply bioenergetics concepts of carbohydrates, Proteins, Lipid and nucleic acids	K3
CO4	Compare, contrast and distinguish proteins, lipids, carbohydrates and nucleic acid metabolism	K4
CO5	Summarize physiological and functional relevance of metabolic pathways.	K5
CO6	Integrate anabolic, catabolic pathways of carbohydrates, proteins, lipids and nucleic acids .	K6

C1 – Remember C2 – Understand C3 – Apply

UNIT I

Introduction to Metabolism: Definition, anabolism, catabolism, metabolic pathways, and importance of carbohydrate metabolic Pathways: glycolysis, citric acid cycle, electron transport chain, pentose phosphate pathway, gluconeogenesis, glycogenesis and glycogenolysis, Entner-Doudoroff pathway.

UNIT II

Amino Acid Metabolism: General reactions of amino acid metabolism - transamination, decarboxylation, oxidative & non-oxidative deamination of amino acids; Special metabolism of methionine, histidine, phenylalanine; Urea cycle and its regulation.

UNIT III

Lipid Metabolism: Introduction - Hydrolysis of triacylglycerols, α-, β-, ω- oxidation of fatty acids; Fatty acid biosynthesis, Lipid biosynthetic pathway; Metabolism of cholesterol and production of bile pigments.

UNIT IV

Nucleic acid Metabolism: Nucleic Acid Biosynthesis; Degradation of purine and pyrimidine nucleotides - Purine salvage pathway; Biosynthesis of deoxy- ribonucleotides and polynucleotides - Inhibitors of nucleic acid biosynthesis.

UNIT V

Coenzymes, Cofactors & Vitamin Metabolism: Role and mechanism of action of NAD+/NADP+, FAD, thiamine pyrophosphate, biotin, pyridoxal phosphate; Biosynthesis of Vitamins – ascorbic acid and folic acid.

TEXTBOOKS:

1. Fundamentals of Biochemistry - J.L. Jain, Sunjay Jain, Nitin Jain, S. Chand &Company.
2. Harper's Biochemistry- Rober K. Murray, Daryl K. Grammer, McGraw Hill, Lange Medical Books. 25th edition.

REFERENCE BOOKS:

1. Biochemistry – Voet and Voet, 4th Edition, WileyPublication
2. Biochemistry- Dr. Amit Krishna De, S. Chand & Co., Ltd.
3. Biochemistry – J. M. Berg, J. L. Tymochzo, L. Stryer (7th Edition) W. H. Freeman PubPublisher.
4. Lehninger. Principles of Biochemistry- David L. Nelson, Michael M. Cox, Macmillan Worth Publishers

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	1	1	9	1	3
CO2	9	1	3	9	1	3
CO3	9	1	3	9	1	3
CO4	9	3	9	9	1	9
CO5	9	3	9	9	3	9
CO6	9	9	9	9	3	9
Weightage	54	18	34	54	10	36

SEMESTER - II		CODE -U21SBE1

Skill Based Elective – Introduction to Bioentrepreneurship Skills		
CREDITS -2		**HOURS -2**

Objectives:

- To teach students about concepts of entrepreneurship
- To help student in identifying a winning business opportunity, gathering funding and
- To educate the student about launching a business, growing and nurturing the organization and harvesting the rewards.

Course Outcomes:

At the completion of the course, the student would be able to:

Cognitive level	Course outcome	Knowledge Level
CO1	Define, basic concepts, theories and definitions of Bio-entreprenurship and accounting practices	K1
CO2	Classify and contrast the different governmental, nongovernmental organizations and financial organization	K2
CO3	Apply, relate and discover the knowledge center, information technology and regulatory compliances in entrepreneurship	K3
CO4	Compare, connect, contrast and differentiate bioindustries, applications and the management	K4
CO5	Judge, value and validate marketing strategies	K5
CO6	Design, develop, or modify bioentrepreneurship role in future needs	K6

C1 – Remember C2 – Understand C3 – Apply

UNIT I

Basics of Bioentrepreneurship

Introduction to bioentrepreneurship – Biotechnology in a global scale, Scope in Bioentrepreneurship, Importance of entrepreneurship. Meaning of entrepreneur, function of an entrepreneur, types of entrepreneur, advantages of being entrepreneur.

UNIT II

Innovation – types, out of box thinking, opportunities for Bioentrepreneurship. Entreprenuership development programs of public and private agencies (MSME, DBT, BIRAC, Startup and Make in India). Patent landscape, IP protection and commercialization strategies.

Management, Accounting and Finance

Business plan preparation: business feasibility analysis by SWOT, Sources of financial assistance – making a business proposal, approaching loan from bank and other financial institutions, budget planning and cash flow management, basics in accounting practices - balance sheet, P&L account, and estimation of income, expenditure and Income tax.

UNIT III

Knowledge Centre and Information Technology

Knowledge centers - Universities, innovation centre, research institutions and business incubators. R&D - technology development and upgradation, assessment of technology development, managing technology transfer, industry visits to successful bio-enterprises, Understanding of regulatory

compliances and procedures (CDSCO, NBA, GLP, GCP & GMP). Use of IT in improving business performance; E-business setup, Digital marketing management.

UNIT IV

Marketing and Human Resource Development

Assessment of market demand for potential product(s) of interest, Market conditions, segments, prediction of market changes, identifying needs of customers including gaps in the market. Branding issues, developing distribution channels – franchising policies, promotion, advertising, branding and market linkages. Marketing of agro products. Recruitment and selection process, leadership skills, managerial skills, organization structure, training, team building and teamwork.

UNIT V

Bioindustries

Definition, characteristics, need and rationale, objectives, scope and advantages of small scale industries. Types of bioindustries – Pharma, Agri and Industry. Biofertilizers production - Azospirillium, Azolla, Cyanobacteria and its applications. Biopecticides production - Bacterial, fungal, viral and plant insecticides. Sericulture. Apiculture. Dairy farming. Single Cell Protein Production and applications. Vermicomposting and its applications. Mushroom cultivation and its application. Ancillary and tiny industries

TEXT BOOKS

1. Adams, D. J., & Sparrow, J. C. (2008). Enterprise for Life Scientists: Developing Innovation and Entrepreneurship in the Biosciences. Bloxham: Scion.
2. Shimasaki, C. D. (2014). Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.
3. Onetti, A., & Zucchella, A. Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge. Routledge.

REFERENCE BOOKS

1. Tripati, P.C and Reddy, P.N (2017). Principles of Management, 6th Edition, Tata Mc Graw Hill.
2. Vasant Desai (2011). Dynamics of Entrepreneurial Development & Management. Himalaya Publishing House Pvt Ltd, India.
3. Charantimath Poornima M. (2005). Entrepreneurship Development – Small Business Enterprises" Pearson Education, India.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	1	1	9	1	3
CO2	9	1	3	9	1	3
CO3	9	1	3	9	1	3
CO4	9	3	9	9	3	9
CO5	9	3	9	9	3	9
CO6	9	9	9	9	3	9
Weightage	54	18	34	54	12	39

SEMESTER - II		CODE – U21MB2P
Core Course II: LAB IN MICROBIAL PHYSIOLOGY		
CREDITS - 3		HOURS - 6

MICROBIAL PHYSIOLOGY

Cognitive level	Course outcome	Knowledge Level
CO1	Choose and practice Pure culture and subculture techniques	K1
CO2	Explain biochemical techniques for microbial identification	K2
CO3	Experiment with direct count and viable count method	K3
CO4	Analyze methods for bacterial growth curve determination	K4
CO5	Determine physiological characteristics of bacteria by different tests	K5
CO6	Design methods for Antibiotic Sensitivity	K6

1. Growth of bacteria on liquid and solid media and their cultural characters.
2. subculture techniques.
3. Biochemical tests for bacterial identification – catalase test –oxidase test – IMVIC test – TSI test – Gelatin liquefaction – starch degradation – carbohydrate fermentation.
4. Viable bacteria –haemocytometer
5. Bacterial Growth Curve- turbidometry
6. Antibiotic Sensitivity Test (Kirby-Bauer Method)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	9	1	3
CO2	3	3	3	9	9	3
CO3	3	9	3	9	1	9
CO4	9	3	9	9	9	9
CO5	9	3	9	9	3	9
CO6	9	9	9	9	3	9
Weightage	36	28	34	54	26	42

SEMESTER–III		CODE: U21MB4

Core course IV- BACTERIOLOGY		
CREDITS:4		**HOURS:4**

Objectives:

- To understand the taxonomy and nomenclature of bacteria.
- To understand various cellular structures.
- To learn bacterial behaviour in solidarity and as communities.
- To understand beneficial interactions of bacteria.
- To learn bacterial pathogenicity.

Course Outcomes:

At the completion of the course, the student would be able to:

Cognitive level	Course outcome	Knowledge Level
CO1	Define bacterial systematics and taxonomy	**K1**
CO2	Illustrate various intra and extracellular structures of bacteria	**K2**
CO3	Classify the concepts of motility, taxis, biofilms and quorum sensing	**K3**
CO4	Examine the beneficial bacterial interactions in the gut-probiotics	**K4**
CO5	Determine the bacterial pathogenicity, cultural characteristics, diagnostics.	**K5**
CO6	Discuss the specific properties of Archaea	**K6**

C1 – Remember C2 – Understand

Unit I

Bergey's Manual of Determinative Bacteriology: Taxonomy, systematics, ecology, physiology and other biological properties of; Archaea (Volume I), The Proteobacteria (volume II), The Firmicutes (volume III), The Bacteroidetes, Spirochaetes, Tenericutes (Mollicutes), Acidobacteria, Planctomycetes and other organisms (volume IV), The Actinobacteria (volume V); Bacterial nomenclature: International Code of Nomenclature of Bacteria (ICNB), Bacteriological Code (BC), Description of new species, culture collections.

Unit II

Cell morphology: Cell wall structure of Gram-positive, Gram-negative cells, Plasma membrane; Extracellular structures: fimbriae and pili, S-layer, Glycocalyx, flagella; Intracellular structures: Bacterial chromosome, extra-chromosomal DNA, Ribosomes (Svedberg units); Intracellular membranes: mesosomes, chromotophores; Nutritional storage structures: polyhydroxyalkanoates, Inclusions, Gas vacuoles, Microcompartments, Endospores.

Unit III

Bacterial motility: principles behind the configuration and function of bacterial flagella, modes of locomotion; swimming, swarming, twitching, gliding motility - non-motile bacteria; Bacterial taxis:

Chemotaxis, aerotaxis, phototaxis, thermotaxis, energy taxis, magnetotaxis; Escape response: geotactic component, cable bacteria, motility as biosignature; Bacterial communication: bioluminescence, biofilms, quorum sensing, bacterial pheromones.

Unit IV

Bacterial commensals: protection in humans, mouse models, Mechanisms of Commensal Bacteria Mediated Protection (Host-Mediated Immunity, direct action), Predatory bacteria: bacteriovorus bacteria, Mutualistic bacteria: anaerobic bacteria with methanogenic archaea, rhizosphere bacteria, normal human gut flora in gut immunity (probiotic activity, competitive exclusion).

Unit V

General attributes of bacteria causing infections, Host Parasite relationships, Mechanism of bacterial pathogenesis: virulence factors, routes of infection, Morphology, classification, cultural characteristics, pathogenicity, laboratory diagnosis and prevention of infections caused by the following organisms: Staphylococcus, Streptococcus, Neisseria, Clostridium, Escherichia coli, Salmonella, Vibrio, Pseudomonas, Mycobacterium, Bacillus.

Text books

1. Atlas RM. (1997). Principles of Microbiology. 2nd edition. WM.T.Brown Publishers.
2. Black JG. (2008). Microbiology: Principles and Explorations. 7th edition. Prentice Hall
3. Madigan MT, and Martinko JM. (2014). Brock Biology of Micro-organisms. 14th edition. Parker J. Prentice Hall International, Inc.
4. Pelczar Jr MJ, Chan ECS, and Krieg NR. (2004). Microbiology. 5th edition Tata McGraw Hill.
5. Srivastava S and Srivastava PS. (2003). Understanding Bacteria. Kluwer Academic Publishers, Dordrecht

Reference books

1. Stanier RY, Ingraham JL, Wheelis ML and Painter PR. (2005). General Microbiology. 5th edition McMillan.
2. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9th edition Pearson Education.
3. Willey JM, Sherwood LM, and Woolverton CJ. (2013). Prescott's Microbiology. 9th edition. McGraw Hill Higher Education.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	3	9
CO2	9	3	3	3	9	9
CO3	9	9	3	9	9	9
CO4	9	9	3	3	3	9
CO5	9	9	9	3	3	3
CO6	9	3	3	3	9	9
Weightage	54	36	30	30	36	48

SEMESTER–III & IV		COURSE CODE: U21MB5P

Core Course V: LAB IN BACTERIOLOGY & MICROBIAL GENETICS AND MOLECULAR BIOLOGY		
HOURS: 6		**CREDITS: 5**

Lab in Bacteriology & Microbial Genetics and Molecular Biology
(Group & Individual practical– under STAR College Scheme)

BACTERIOLOGY

Cognitive level	Course outcome	Knowledge Level
CO1	Select general requirements for collection and transport of clinical specimens	**K1**
CO2	Summarize different staining methods to analyze clinical materials	**K2**
CO3	Identify bacterial pathogens from clinical specimens	**K3**
CO4	Decipher methods for isolation of human microflora	**K4**
CO5	Measure antibiotic sensitivity pattern	**K5**
CO6	Predict minimum inhibitory concentration of antibiotics	**K6**

1. General requirements of collection, transport of clinical specimens, direct examination.
2. Simple, differential and special staining of clinical material.
3. Isolation and identification of bacterial pathogens from clinical specimens.
4. Isolation of microflora from the human microbiome.
5. Antimicrobial sensitivity testing and determination of MIC and quality control.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	9	9	3	9
CO2	9	3	9	3	9	9
CO3	9	9	3	9	9	9
CO4	9	9	3	3	3	9
CO5	9	9	9	9	9	3
CO6	9	3	3	3	9	9
Weightage	54	42	36	36	42	48

SEMESTER– IV		COURSE CODE: U21MB5P
Core Course V: LAB IN MICROBIAL GENETICS AND MOLECULAR BIOLOGY		
HOURS: 6		CREDITS: 5

MICROBIAL GENETICS & MOLECULAR BIOLOGY

Cognitive level	Course outcome	Knowledge Level
CO1	Find proteins by SDS- PAGE	K1
CO2	Outline spectrophotometric analysis of nucleic acids	K2
CO3	Solve methods for isolation of plasmid DNA	K3
CO4	Analyze spontaneous mutants	K4
CO5	Elucidate bacterial conjugation	K5
CO6	Build AMES test for carcinogen	K6

1. Isolation of Plasmid DNA.
2. Estimation of nucleic acids
   a) UV - VIS spectrophotometer analysis.
   b) Analysis of nucleic acids by agarose gel electrophoresis.
3. Detection of proteins by SDS-PAGE
4. Isolation of spontaneous mutant: antibiotic resistant mutants
5. Isolation of auxotrophic mutant by chemical and UV mutagenesis
6. AMES test.
7. Uninterrupted bacterial conjugation. (Demonstration)
8. Isolation of phage.

References

1. Baily and Scott's Diagnostic Microbiology, 2006. Mosby, London.
2. Collins and Lyne's Microbiological methods, 2001. Arnold publishers, New York.
3. Palanivelu P. Analytical Biochemistry & Separation Techniques 4/e, 21st Century Publication, Palkalai Nagar, Madurai - 625 021(2004).
4. Maniatis T., Fritsch E.F. & Sambrook J. Cold Spring, Molecular Cloning, A laboratory manual, Cold Spring Harbor laboratory (2002).
5. David R.W, Botstein D & Roth J.R., Advanced bacterial genetics, Cold Spring Harbor laboratory (1980).

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6

CO1	9	9	9	9	3	9
CO2	9	3	9	3	9	9
CO3	9	9	3	9	9	9
CO4	9	9	9	3	9	9
CO5	9	9	9	9	9	3
CO6	9	9	3	3	9	9
Weightage	54	48	42	36	48	48

SEMESTER - III		CODE – U21AMB4
Allied Course IV: BIOINSTRUMENTATION		
CREDITS - 4		HOURS – 4

Objectives:

To understand the rationale behind the selection of analytical methods for variousbiological applications.

To understand the real-time applications of spectroscopic and microscopic techniques.

To understand the working and applications of structural elucidation techniques.

To learn the principle and working of chromatographic techniques.

To understand the working and applications of electrophoretic techniques.

Course Outcomes:

At the completion of the course, the student would be able to:

Cognitive level	Course outcome	Knowledge Level
CO1	Define basic concepts, theories and definitions of analytical methods	K1
CO2	Classify and contrast the techniques in structural elucidation of biomolecules	K2
CO3	Apply, relate and discover the techniques used in imaging and analytical methods	K3
CO4	Compare, contrast and differentiate techniques to separate and quantify biomolecules	K4
CO5	Summarize separation methodologies of proteins, nucleic acid and validate	K5
CO6	Design or modify methods for separation of proteins, carbohydrates and nucleic acids.	K6

C2 – Understand C3 – Apply

UNIT I

Selection of analytical methods; Performance Indicators: Accuracy, Precision, Detection Limit, Sensitivity and Analytical Range; Types of errors: Random and Systematic; Calibration methods: Standard curve and Internal standard addition.

UNIT II

Spectroscopic Techniques: Principle, Instrumentation, Working and Applications of UV-Visible, IR and Fluorescence spectroscopy.

Microscopic Techniques: Principle, Instrumentation, Working and Applications of Scanning Electron Microscopy, Transmission Electron Microscopy, Confocal Microscopy and Flow Cytometry.

UNIT III

Structure Elucidation Techniques: NMR, MS–Ionization (MALDI, ESI), Analyzer (TOF and Quadrupole) and Detector.

Centrifugation: Principle, Types (Differential, Ultra and industrial centrifugation) and Applications.

UNIT IV

Chromatographic Techniques: Theories on chromatography - Rate and Plate theory, Van Deemter equation, Resolution of chromatography; Principle, Instrumentation, Working and Applications of Thin Layer, Adsorption, Gel Exclusion, Ion exchange, Affinity, Liquid (HPLC, FPLC) and Gas chromatography.

UNIT V

Electrophoretic Techniques: Principle, Instrumentation, Working and Applications of Gel (Agarose, PAGE and SDS-PAGE), Capillary and Pulse Field Electrophoresis; Isoelectric focusing: Theory, Instrumentation and Applications.

TEXT BOOKS

1. Wilson, K., and J. Walker. (2010). Principles and Techniques of Practical Biochemistry and Molecular Biology, 7th Edition, Cambridge University Press, U.K.
2. Skoog, D. A., Holler, F. J., and S. R. Crough. (2007). Instrumental Analysis, 6th Edition, Brooks Cole Publishing Company, USA.

REFERENCE BOOKS

1. Chatwal, G.R., and Anand, S.K. (2019). Instrumental Methods of Chemical Analysis, 5th Edition, Himalaya Publishing House, India.
2. Sharma, B.K. (2014). Instrumental Methods of Chemical Analysis, 24th Edition, GOEL Publishing House, India.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	1	1	9	1	3
CO2	9	1	3	9	1	3
CO3	9	1	3	9	1	9
CO4	9	3	9	9	1	9
CO5	9	3	9	9	3	9
CO6	9	9	9	9	3	9
Weightage	54	18	34	54	10	42

SEMESTER - III & IV		CODE – U21AMB5P
Allied Course V: LAB IN BIOINSTRUMENTATION & BIOSTATISTICS		
CREDITS – 3		HOURS - 6

Lab in Bioinstrumentation & Biostatistics
(Group & Individual practical– under STAR College Scheme)

Cognitive level	Course outcome	Knowledge Level
CO1	Define basic concepts, theories and definitions of analytical methods	K1
CO2	Extract biomolecules from various biological sources	K2
CO3	Apply, relate and discover the techniques used in imaging and analytical methods	K3
CO4	Estimate and quantify the amount of biomolecules from various biological samples	K4
CO5	Summarize separation methodologies of proteins, nucleic acid and validate	K5
CO6	Design or modify methods for separation of proteins, carbohydrates and nucleic acids	K6

1. Spectrophotometric Evaluation of dyes by UV-Vis spectrophotometry
2. DNA quantification using UV-Vis spectrophotometry
3. DNA isolation from bacterial culture
4. DNA visualization by Gel electrophoresis
5. Paper chromatography
6. Lyophilization
7. SEM (Demonstration)
8. Flow Cytometer (Demonstration)
9. SPSS Software (Demonstration)

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6

CO1	9	1	1	9	1	3
CO2	9	1	3	3	1	3
CO3	9	1	3	9	1	9
CO4	9	3	9	9	1	9
CO5	9	3	9	9	3	9
CO6	9	9	9	9	3	9
Weightage	54	18	34	51	10	42

SEMESTER – III		CODE – U21SBE2
Skill Based Elective – Bioentrepreneurship-I		
CREDITS – 2		HOURS – 2

Objectives:

- To understand the concepts of macropropagation, vermicomposting, mushroom cultivation, apiculture and cuniculture
- To interpret the market analysis data for planning for entrepreneurship projects.
- To understand the workings of management, institutions and governing bodies with regards to running a business.

Course Outcomes:

At the completion of the course, the student would be able to:

Cognitive level	Course outcome	Knowledge Level
CO1	Define, concept, production and management bioindustries	K1
CO2	Describe the structural and production aspects of the mushroom cultivation, vermicompost, Apiculture and cuniculture	K2
CO3	Apply the concepts of bioindustries to start and run a production facility	K3
CO4	Compare, connect, contrast and different bioindustries, applications and the management	K4
CO5	Judge, value and validate marketing strategies	K5
CO6	Design, develop, or modify bioentrepreneurship role in future needs	K6

C1 – Remember C2 – Understand C3 – Apply

Unit I

Mushroom cultivation

Introduction to mushroom culture; Historical background; Present status of mushroom culture in India. Cultivation methods – infrastructure substrates; Preparation of spawns; Formulation and preparation of composts; Spawn running and cropping; Control of pathogens and pests. Cultivation of *Volvariella* sp. *Pleurotus* sp. and *Agaricus bisporus*. Nutritional values, Recipes from Mushroom.

Unit II

Macropropagation

Introduction to Macropropagation and their different types - *In-situ*, detach and split advantages and disadvantages. Selection of mother plants-different substrate for propagation- developmental stages of plants - primary, secondary and tertiary. Application of Macropropagation.

Unit III

Vermiculture

Introduction-Compost development, Quantification and characterization of solid waste, factors responsible for composting. Earthworm- rearing, role of earthworms in vermicompost, vermispecies, earthworms and microorganisms- vermicompost- methods and steps, nutrition enrichment- applications of vermiculture.

Unit IV- Apiculture

Introduction to Bees and Beekeeping-Overview of Beekeeping; History- Species of honey bees- life history- bee colony, castes, developmental significance of social life- natural colonies and their yield. Bee Flora and Pollination. Bee Health Management-Bee Enemies and their Management, Bee-Diseases and their Management, Protection from Poisoning. Seasonal and Specific Management. Products Collected and Modified by Bees (Honey, Propolis and Pollen). Products Synthesized by Bees (Bee's Wax-Royal Jelly-Bee Venom). Marketing, Economics and Development Programmes.

Unit V -Cuniculture

Introduction to rabbit and breeds- Advantages and disadvantages; handling methods; types of feeds; rearing methods; disease managements; commercial applications.

TEXT BOOKS

1. Bahl Neeta. 1984. Handbook on mushrooms. Oxford and IBH Publishing Co., New Delhi. 123 p
2. Emmanuel Njukwe, Abdou Tenkouano, Delphine Amah, Kassim Sadik, Perez Muchunguzi, Moses Nyine and Thomas Dubois Macro-Propagation Propagation Propagation Of Banana And Plantain (2016).International Institute of Tropical Agriculture, Cameroon or Uganda.
3. Glenn Munroe (2006),Manual of On-Farm Vermicomposting and Vermiculture. Organic Agriculture Centre of Canada.
4. Gupta, J.K., Sharma, H K and Thakur, R K. 2009. Practical Manual on Beekeeping.Department of Entomology and Apiculture, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, p 83.
5. Lebas,F. (1997). The rabbit - Husbandry, health and production, FAO Animal Production and Health Series No. 21.

REFERENCE BOOKS

1. Chang, S.T. and Miles, P.G. 2004. Mushroom cultivation: nutritional value, medicinal effect and environmental impact. CRC Press, Boca Raton. 451p
2. Njukwe, Emmanuel & Ouma, Emily & Van Asten, Piet J.A. & Muchunguzi, Perez & Amah, Delphine. (2013). Challenges and Opportunities for Macropropagation Technology for *Musa* spp. among Smallholder Farmers and Small and Medium-scale Enterprises. 10.1079/9781780642314.0066.
3. Handbook of Vermicomposting Technology (1999).Sreenivasan,E.The Western India Plywoods Ltd
4. Mishra R.C. (1995) Honey bees and their management in India. ICAR Publication, New Delhi.
5. Cuniculture (2013).Source Wikipedia, University-Press.org, 1230687955.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	1	1	9	1	3
CO2	9	1	3	9	1	3
CO3	9	1	3	9	1	3
CO4	9	3	9	9	3	9
CO5	9	3	9	9	3	9
CO6	9	9	9	9	3	9

SEMESTER – III		CODE – U21SBE3
Skill Based Elective – Bioentrepreneurship-II		
CREDITS – 2		HOURS – 2

Objectives:

- To understand the concepts of biofuels, wine productions, molecular diagnostics and food testing & analysis.
- To learn how to find and equip themselves for a technical position in a corporation dealing with the above businesses.
- To understand the workings of management, institutions and governing bodies with regards to running a business.

Course Outcomes:

At the completion of the course, the student would be able to:

Cognitive level	COURSE OUTCOMES	Knowledge level
CO1	Understand the concepts of biofuel production	K1
CO2	Learn about the types of molecular diagnostics and food testing analyses that can be applied in real world	K2
CO3	Utilize the concepts of fermentation in the production of wine	K3
CO4	Understand and apply the mechanisms of plant-microbe interactions for development of inoculums to be used as biofertilizers	K4

C1 – Remember C2 – Understand C3 – Apply

Unit I- Biofuel production

Biomass as energy source, opportunities and challenges, form of Biomass-Solid, liquid, gas, Different generation of biomass- first, second and third, Introduction to biofuel: oleaginous microbes-Microalgae, yeast and bacteria, Low-cost feedstock and microbes used for advance biofuel production-Bioethanol and biobutanol. Transesterification and fatty acid analysis, Biodiesel quality standard and economics. Biofuel and biorefinery.

Unit II - Molecular Diagnostics

Genetic abnormalities and inherited diseases; Cytogenetic techniques in the detection of Inherited disorders-karyotyping, FISH.

An introduction to single nucleotide polymorphisms, haplotypes and linkage analysis. Utilization of PCR in molecular diagnosis, designing of primers, diagnostic methods for Inherited diseases including Congenital Adrenal hyperplasia, Type I Diabetes, Maturity onset diabetes of the young (MODY); sequencing of PCR products, whole Exon sequencing for the diagnosis of Inherited diseases.

Unit III- Food testing and Analysis

Basic testing: physiochemical parameters, nutritional analysis, Microbial analysis, Heavy metals, stability testing. Introduction about FSSAI license, ISO 22000/ISO22002 for unit, AYUSH certificates.

Unit IV - Wine production

Viticulture: Introduction to viticulture, definition and terminologies. Classification of wine: Generic classification, varietal classification. Raw materials and equipment use in wine production: crusher, press fermenter, filtration and additives used in wines. White wine-production and recommended

varieties. Red wine-production and recommended varieties. Fortified wine-production and recommended varieties. Production of wine from fruits other than grapes.

Unit V- Biofertilizers:

Microbial biofertilizers, types. Customization strategies for field/soil condition, Targeted isolation and selection, Mass production methods, Preparation and storage, Delivery strategies to crops. Traditional biofertilizers, preparation methods and advantages. Vemicompost - production, storage and logistics.

TEXT BOOKS

1. Ozcan Konur. 2017. Bioenergy and Biofuels. CRC Press, Taylor & Francis Group. ISBN 9781351228138.
2. Lela Buckingham and Maribeth L Flaws. (2007). A review of molecular diagnostics: Fundamentals, methods and Clinical Applications. F. A. Davis Company, Philadelphia.
3. Molecular Diagnostics, 3rd Edition; George Patrinos Wilhelm Ansorge Phillip B. Danielson, (2017) Academic Press.
4. Manual of Methods of Analysis of Foods (2016). Food Safety and Standards Authority of India Ministry of Health and Family Welfare Government of India, New Delhi.
5. Grainger, K. and Tattersall,H.(2016) Wine Production and Quality, Print ISBN:9781118934555 |Online ISBN:9781118934562 |DOI:10.1002/9781118934562.
6. Mahendra K. Rai (2005). Hand book of Microbial biofertilizers, The Haworth Press, Inc. New York.

REFERENCE BOOKS

1. Luque,R. and Campelo,J.M. and Clark, J.H. (2011). Hand Book of Biofuel production,Woodhead Publishing Limited,
2. Diagnostic Molecular Pathology: A Guide to Applied Molecular Testing, 1st Edition. William Coleman Gregory Tsongalis (2016) Academic Press.
3. Nielsen,S.S.(2017). Food Analysis, Food Science Texts Series, ISBN : 978-3-319-44125-2.
4. Kannaiyan, S. (2003). Biotechnology of Biofertilizers, CHIPS, Texas.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	9	1	3
CO2	3	1	3	9	1	3
CO3	3	9	3	9	9	9
CO4	9	3	9	9	9	9
CO5	9	3	9	9	3	9
CO6	9	9	9	9	3	9
Weightage	36	27	34	54	26	42

SEMESTER –III		CODE - U21SBE4/5P
PART – IV: Skilled Based Elective Bioentrepreneurship-I and Bioentrepreneurship-II		
CREDITS – 3		HOURS – 6

Lab in Bioentrepreneurship-I and Bioentrepreneurship-II
(Group & Individual practical – under STAR College Scheme)

Bioentrepreneurship-I

1. Spawn preparation for mushroom cultivation.
2. Bed preparation for mushroom cultivation.
3. Explant preparation for primary, secondary and tertiary for macropropgation.
4. Vermicompost bed preparation.
5. Physical parameter analysis in vermicompost.
6. Honey and wax extraction method
7. Species identification
8. Disease management

Bioentrepreneurship-II

1. Inoculum preparation for biofertilizer.
2. Azolla cultivation.
3. Molecular diagnosis of CAH (Congential Adrenal HP).
4. Determination of the risk of incidence of T2DM in healthy teaching faculty.
5. Molecular diagnosis of monogenic disease (MONY3).
6. Food testing and analyses in food samples.
7. Wine Production in different fruits.

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	1	9	9	3
CO2	9	1	3	9	9	3
CO3	9	9	3	9	1	3
CO4	9	3	9	9	3	9
CO5	9	3	9	9	3	9
CO6	9	9	9	9	3	9
Weightage	54	34	34	54	28	39

SEMESTER – IV		CODE – U21MB6
Core Course VI: MICROBIAL GENETICS AND MOLECULAR BIOLOGY		
CREDITS – 4		HOURS – 4

Objectives

- To understand the experimental evidences on the genetic material and gain knowledge on its structure.
- To understand the process involved in gene expression, protein synthesis and DNA repair.
- To discuss gene regulatory mechanisms.
- To acquire knowledge on the types of plasmids and gene transfer mechanisms.
- To understand about bacteriophages and its cycle.

Course Outcomes (CO)

On successful completion of the course, students will be able to

Cognitive level	COURSE OUTCOMES	Knowledge level
CO1	List out the properties, structure and function of genes in living organisms at the molecular level	K1
CO2	Summarize the basic concepts in genetic material and its replication	K2
CO3	Apply knowledge about the genetic material transfer mechanisms	K3
CO4	Analyze the molecular mechanisms, mutations, detection of mutations and DNA damage and repair	K4
CO5	Evaluate the molecular mechanisms involved in transcription and translation	K5
CO6	Compile the various methods of gene regulatory mechanisms	K6

UNIT I

DNA as the genetic material –History, discovery of DNA structure; RNA as a genetic material- Structural features of RNA (rRNA, tRNA, and mRNA); Griffith, Avery, Hershey & Chase experiments on proving DNA as the genetic material; DNA replication, general principles and various modes of replications- Semi conservative model- Meselson and Stahl experiment, replication of circular DNA molecule- conservative, rolling circle mechanism, θ mode of replication.

UNIT II

Gene expression and protein synthesis: Transcription- general principles & steps: initiation, elongation and termination; Translation: initiation, elongation and termination; Gene as a unit- mutation and recombination; Molecular nature of mutations; Mutagenesis; DNA damage and repair: type of DNA damage (deamination, oxidative damage, alkylation, pyridine dimers); Repair mechanisms –methyl directed mismatch repair, very short patch repair, nucleotide excision repair, base excision repair, recombination repair, SOS system.

UNIT III

Types of gene regulation; gene regulatory mechanisms in microbes: operon model –*lac* operon, tryptophan operon, galactose operon; Concept of Feedback Inhibition; Regulation of Eukaryotic genes - Transcription factor based regulation.

UNIT IV

Types of plasmids (F Plasmid: a Conjugate plasmid); Mobilization of Non-conjugative plasmid, R plasmid, Col plasmid Copy number and incompatibility); Episomes; Bacterial Genetics -Transposable elements (Insertion sequence and transposons, Integrons and Antibiotic-Resistance cassettes, multiple antibiotic resistant bacteria, Mu–virus, Mutant phenotype, DNA mediated Transformation; Conjugation (Cointegrate Formation and Hfr Cells, Time–of–Entry Mapping, F' Plasmid); Transduction (Generalized transduction, Specialized Transduction)- gene mapping.

UNIT V

Bacteriophages: Stages in the Lytic Life Cycle of a typical phage; Properties of a phage infected bacterial culture; Specificity in phage infection; *E. coli* PhageT4, T7; *E.coli* phage lambda; Immunity to infection; Prophage integration; Induction of prophage; Induction & Prophage excision; Repressor; Structure of the operator and binding of the repressor and the Cro product; Decision between the lytic and lysogenic Cycles; Transducing phages; Phage phiX174; the lysogenic cycle.

TEXT BOOKS

1. Turner, P.E., McLennan, A.G., Bates, A.D. and White, M.R.H. 1999. Instant Notes in Molecular Biology, Viva Books Ltd., New Delhi.
2. Watson, J. D., Hopkins, N. H., Roberts, J. W., Steitz, J. A., & Weiner, A. M. Molecular biology of the Gene 4/e, The Benjamin/Cumming Publishing Company Inc.1992.
3. Snyder L & Wendy W. Molecular Genetics of Bacteria, 2/e, ASM press, Washington DC, 2003.

REFERENCES

1. Benjamin Lewin. Gene VII: Oxford University Press: 2000.
2. David Freifelder.D.2008. Microbial Genetics, Eighteenth Edition, Narosa Publishing house, New Delhi.
3. Freifelder, D. 2000. Molecular Biology, Second Edition, Narosa Publishing house. New Delhi.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	9	9	3	9
CO2	9	3	9	3	9	9
CO3	9	9	3	9	3	9
CO4	3	9	1	3	9	9
CO5	9	3	9	1	3	3
CO6	9	3	9	9	9	9
Weightage	48	36	40	34	36	48

SEMESTER – IV						**CODE – U21AMB6**
Allied Course VI: BIOSTATISTICS						
CREDITS – 4						**HOURS – 4**

Objectives:

- To understand the significance of statistical analysis in biology.
- To discuss the significance of statistical measures in biology.
- To learn the application of regression analysis in practical applications.
- To understand the basics of hypothesis testing and statistical significance.
- To acquire knowledge on various statistical tools available for the analysis of biological data.

Course Outcomes:

On completion of the course, the student would be able to:

Cognitive level	COURSE OUTCOMES	Knowledge level
CO1	Define the elements of statistics including data collection methods, experimental designs and analysis methods	K1
CO2	Explain the data types and sampling methods with measures of errors	K2
CO3	Apply data representation methods, Measures of central tendency and deviation in correlation and significance analysis	K3
CO4	Examine data correlation and regression models for statistical analysis	K4
CO5	Assess statistical significance using parametric and non-parametric tests	K5
CO6	Develop experimental designs with statistical validation	K6

C1 – Remember C2 – Understand C3 – Apply

UNIT I:

Statistical Measures: Measures of Central tendency: Mean and its types, Median and Mode – Measures of Variation: Mean deviation and Standard deviation – Standard error – Correlation: Karl Pearson's Correlation Coefficient and Spearman's Rank Correlation Coefficient.

UNIT II:

Hypothesis Testing: Null and Alternative hypotheses–Type I and Type II errors – Level of significance – Small sample testing based on t and F distributions: single mean, difference of means, paired t-test and variance ratio test – Large sample testing: single mean, difference of means, single proportions and difference of proportions – Chi square test for Goodness of fit and Independent of attributes.

UNIT III:

Non – Parametric tests: Kruskal-Wallis test – Mann-Whitney U test – Rank test. Analysis of Variance: One way ANOVA.

UNIT IV:

Curve fitting: Regression: Linear and simple linear regression, Curve of regression – Least square method for straight lines and curves.

UNIT V:

Design of Experiments: Single factor experiments – Completely Randomized Design – Randomized Block Design – Latin Square Design – Factorial Design- Plackett Burmann Design – Response Surface Methodology. Introduction to Software Packages: SPSS and MATLAB

TEXT BOOKS

1. Veer Bala Rastogi, "Fundamentals of Biostatistics ", Ane books Pvt. Ltd, Second edition , 2009.
2. Gupta S. P, "Statistical Methods", Sultan Chand & Sons Publishers, 2004.

REFERENCE BOOKS

1. Walpole R. E., Myers S.L. & Keying Ye, "Probability and Statistics for Engineers and Scientists", Pearson Education Inc, 2002.
2. Jerrold H. Zar, Biostatistical Analysis, 4/e, Prentice Hall, 1999.
3. Douglas C. Montgomery, Design and Analysis of Experiments,7/e, Wiley, 200

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	9	3
CO2	9	3	9	9	9	3
CO3	9	3	9	9	9	9
CO4	9	3	9	9	9	9
CO5	9	3	9	9	9	9
CO6	9	3	9	9	9	9
Weightage	54	18	54	54	54	42
Weightage %						

SEMESTER – V		CODE – U21MB7
Core Course VII: MYCOLOGY AND PARASITOLOGY		
CREDITS – 5		HOURS - 5

Objectives:

- To acquire knowledge on different types of fungi.
- To learn fungal taxonomy, growth and metabolism.
- To learn about fungal diseases.
- To understand the concepts in parasitology and host-parasite interaction.
- To gain knowledge on parasitic diseases.

Course Outcomes:

At the completion of the course, the student would be able to:

Cognitive level	Course outcomes	Knowledge level
CO1	Define the basic properties and classification of fungi	K1
CO2	Explain about the fungal taxonomy and systematics	K2
CO3	Categorize animal and plant diseases caused by fungi	K3
CO4	Examine the concept of parasitism and host-parasite Interaction	K4
CO5	Assess basic morphology, life cycle, pathogenesis of parasites, Laboratory diagnosis methods and treatment.	K5
CO6	Elaborate the Diversity of fungi and fungus-like organisms and fungal reproduction.	K6

C1 – Remember C2- Understand

Unit I

Historical developments in Mycology; General characteristics of fungi (molds and yeast) including habitat, distribution, nutritional requirements; Diversity of fungi and fungus-like organisms; Economic importance of fungi in agriculture, environment, industry, medicine, food, biodeterioration and mycotoxins.

Unit II

Fungal taxonomy and systematics; Fungal morphology; Fungal cell ultrastructure: thallus organization and aggregation, wall structure and synthesis, asexual reproduction, sexual reproduction, heterokaryosis, heterothallism and parasexual mechanism; Growth and metabolism.

Unit III

Fungal diseases in plants: wart disease of potato, white rust of crucifers, leaf curl of peaches, smut disease of onion and leaf spot disease of groundnut; Fungal diseases in animals: mycoses, mycotoxicoses, phycomycoses, candidiasis, dermatophytosis, aspergillosis, otomycosis, penicillinosis.

Unit IV

Introduction to parasitology; Classification of parasites; Types of parasitism (commensalism, symbiosis, and predatorism); Types of Hosts (final, intermediate, paratenic and reservoir), Vectors; Sources of parasitic infections; Host-parasite interactions and types of parasites.

Unit V

Symptoms, causes, prevention and life cycle of parasitic protozoa: *Toxoplasma gondii*, *Plasmodium vivax*, *Giardia lamblia*, *Trypanosoma gambiense*, *Entamoeba histolytica* and *Cryptosporidium parvum*.

TEXT BOOKS

1. Manoharachary, C., Tilak, K.V.B.R. Mallaiah, K.V. Kunwar I.K. (2016). Mycology and microbiology, Scientific Publishers (India).
2. Brooks G.F., Carroll K.C., Butel J.S., Morse S.A. and Mietzner, T.A. (2013). Jawetz, Melnick and Adelberg's Medical Microbiology. 26th edition. McGraw Hill Publication.
3. Chatterjee KD, (2019). Parasitology, Protozoology and Helminthology. 13th Edition, CBS Publisher, India.

REFERENCE BOOKS

1. Jagdish Chander (2018). A Textbook of medical mycology, Fourth Edition, Jaypee Brothers Medical Publishers.
2. Alexopoulos C.J., Mims C.W., Blackwell M.M., (1996). Introductory Mycology, 4th Edition, Published by Wiley.
3. Jayaram Paniker C.K. (2018). Textbook of Medical Parasitology, 7th Edition, Jaypee Brothers Medical Publishers.
4. Chakraborthy, P. (2006). A TextBook of Microbiology. New Central book agency, Kolkata.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	9	9
CO2	9	9	3	3	9	9
CO3	9	3	3	9	3	9
CO4	3	9	1	3	9	9
CO5	3	1	3	3	3	3
CO6	9	3	9	9	9	9
Weightage	42	28	28	36	42	48

SEMESTER - V		CODE – U21MB8
Elective Course I: VIROLOGY		
CREDITS - 5		HOURS – 5

Objectives:

- To learn distinctive properties of viruses.
- To acquire knowledge on viruses infecting prokaryotes.
- To learn different types of plant diseases caused by viruses.
- To acquire knowledge on different types of viruses causing diseases in animals.
- To learn their methods of cultivation, diagnosis, preventive and treatment measures.

Course Outcomes:

On successful completion of the course, learner will be able to:

Cognitive level	COURSE OUTCOMES	Knowledge level
CO1	List the basic properties, classification of viruses and related agents	K1
CO2	Explain about bacteria, viruses and its life cycle	K2
CO3	Classify viral infections, their diagnosis and therapy	K3
CO4	Analyze the general characteristics of plant viruses	K4
CO5	Reveal the clinical aspects of animal viruses	K5
CO6	Elaborate the Identification of viruses by immunological and molecular techniques	K6

C1 – Remember C2- Understand

Unit 1

History and general properties of viruses; Morphology, ultrastructure and chemical composition- proteins and nucleic acids; Nomenclature and classification; Sub viral particles (viroids, virion, prions, & satellite viruses): discovery, structure, replication and diseases.

Unit II

Different classes of bacterial viruses: bacteriophages (T7, lambda and M13 phage) and cyanophage; Life cycle - lytic and lysogenic; Lysogenic repression; Viral genetics: RNA, DNA, single strand and double strand genomes, and their general characteristics.

Unit III

Plant viruses: Morphology, general characteristics, propagation & purification; Plant-viral disease epidemiology, symptoms, diagnosis, prevention and treatment; DNA virus-Cauliflower mosaic virus, RNA virus- Tobacco mosaic virus.

Unit IV

Animal viruses: morphology, general properties, culture- cell line & embryonated egg; Animal-viral diseases: epidemiology, clinical symptoms, lab diagnosis and treatment; DNA viruses-Orthopox, Pox; RNA viruses- Corona and Polio virus.

Unit V

Identification of viruses; Interferons & Antiviral agents; Immune & molecular diagnosis: sero-diagnosis, antibody assay, hemagglutination, complement fixation test, immunofluorescence test, immunoassay, Western blot, hybridization and RT-PCR; Viral vaccines and phage therapy.

TEXTBOOKS

1. Levy JA, Conrat HF, Owens RA. (2000). Virology. 3rd edition. Prentice Hall publication, New Jersey.
2. Oarsman S.N.J., van Zyl G.U., Nutt L., Anderson M.I. and Preiser W. (2012) Virology Illustrated colour text, 1st Edn. Elsevier Health Sciences.
3. Singh V. (2010) Text book of Virology, 1st Edn. IBDC publishers.

REFERENCE BOOKS

1. Wagner EK, Hewlett MJ. (2004). Basic Virology. 2nd edition. Blackwell Publishing
2. Carter J and Saunders V. (2007). Virology: Principles and Applications. John Wiley and Sons.
3. Diagnostic Microbiology, Bailey and Scott's., 1990. Eighth edition. The Mosby Company.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	9	9
CO2	9	9	3	9	9	9
CO3	9	3	3	9	3	9
CO4	3	9	3	3	9	9
CO5	9	3	3	3	9	3
CO6	9	3	9	9	9	9
Weightage	48	30	30	42	48	48

SEMESTER -V		CODE – U21MB9P
Core Course Lab IX LAB FOR COURSES IN SEMESTER V		
CREDITS - 4		HOURS - 6

LAB FOR COURSES IN SEMESTER V

(Group & Individual practical – under STAR College Scheme)

Cognitive level	COURSE OUTCOMES	Knowledge level
CO1	Enumerate total WBC and RBC	K1
CO2	Illustrate preparation of serum components	K2
CO3	Select methods for isolation of bacteriophage	K3
CO4	Compare radial and double immunodiffusion tests	K4
CO5	Estimate the haemoglobin content	K5
CO6	Visualize restriction digestion and ligation of digested DNA	K6

1. Restriction digestion of DNA
2. Ligation of digested DNA
3. Transformation (Group)
4. Selection and Screening
5. Blood Grouping
6. Total WBC and RBC
7. Estimation of Haemoglobin
8. Preparation of Serum components
9. Radial Immunodiffusion test
10. Double Immunodiffusion test
11. Viruses – Bacteriophage isolation
12. Plaque formation assay

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	9	9	9	9	9
CO2	9	9	3	9	9	9
CO3	9	3	9	9	3	9
CO4	3	9	3	9	9	9
CO5	9	3	9	3	3	9
CO6	3	9	9	3	9	9
Weightage	45	42	42	42	42	54

SEMESTER - V		**CODE-U21MB10E**
Core Course IV: IMMUNOLOGY		
CREDITS-5		**HOURS-5**

Objectives

- To understand the cells and organs of the immune system.
- To acquire knowledge on antigen-antibody interactions.
- To understand the components and mechanisms of cell mediated immunity.
- To learn the defence mechanisms in prokaryotes.
- To learn the defence system that exists in fungal organisms.

Course Outcomes:

On successful completion of the course, the students will be able to

Cognitive level	COURSE OUTCOMES	Knowledge level
CO1	Enumerate the components of the Immune system	K1
CO2	Outline the Antigen-Antibody interactions and their applications in diagnosis	K2
CO3	Apply Hybridoma Technology for MAb production	K3
CO4	Decipher the mechanisms of defense that operate in prokaryotes	K4
CO5	Elucidate fungal immune response	K5
CO6	Compile the role of cells in immune system	K6

UNIT I

Overview of immune system; Immunity: innate, acquired; Haematopoiesis; Cells, tissues and organs of the immune system; Interrelationship between innate and adaptive immunity; Antigens and antigenicity: properties, epitope, paratope, hapten, adjuvants; Immune response and its types; Antibodies: structure, types & function.

UNIT II

Antigen-Antibody complex; *In vitro* testing: agglutination, precipitation, ABO blood grouping & Rh typing, ELISA, RIA, IF, Flow cytometry, HA & HI, and CFT; *In vivo* testing: Skin tests, immune complex tissue demonstrations; Clonal selection theory; Monoclonal antibodies and its applications; Hybridoma Technology for MAb production; Complement: structure, properties and pathways.

UNIT III

Cell Mediated Immunity; T-cells and types; MHC, Antigen processing and presentation; Cytokines: Interleukins and interferons; Hypersensitivity - Types; Autoimmune diseases; Immune tolerance; Transplantation Rejection: Graft Vs Host and Host Vs Graft; Tumor immunology; Tumor associated antigens; Immune response to tumor; Vaccines: types – live attenuated, killed, purified polysaccharide, toxoid, recombinant and DNA vaccines.

UNIT IV

Diversity of defence systems in prokaryotes; Need for multiple defences; Gain and loss of defence systems; Pan-immunity as a shared resource; Microbial draft genomes; Idiosyncratic loci; Adaptive immune system of prokaryotes against viral DNA; Impeding entry of viruses; Restriction enzymes; CRISPR associated proteins (Cas); CRISPR-Cas types: Type I, II & III; DNA targeted CRISPR-mediated defence; RNA-guided Cas nucleases; CRISPR loci in archaea; A perspective on the future of CRISPR immunity.

UNIT V

Innate immune responses of fungi; Fungal Nucleotide Oligomerization Domain (NOD)-like receptors (NLRs); NLRs mediate non-self-recognition; Role of het (or vic) genes in self and nonself recognition; Diversity, role, evolution, response initiation and signal recognition by fungal NLRs; The VI process; Fungal immune responses; Autophagy; Secondary metabolites; Cell wall modifications; Role of fungal NLRs controlling VI in bacterial–fungal interactions.

TEXTBOOKS

1. Punt J, Sharon Stranford, Patricia Jones and Judith A Owen. J. Kuby Immunology (2018) 8th ed. WH Freeman.
2. Roitt, I.M., M.David Roth, Jonathan Brostoff and David Male (Editors). Immunology (2012) 8th Edn, Elsevier Saunders, London, UK.
3. Richard Coico and Geoffrey Sunshine. Immunology: A Short Course, (2015) 7th Edn,Wiley Blackwell, NY.

REFERENCE BOOKS

1. Gabrial Virella (Editor) Medical Immunology (2001) 5th Edition, Marcel Dekkar, NY.
2. Weir M. D. and J. Stewart, Immunology (1997), 8th Ed., Churchill Livingston, USA.
3. Roitt, I.M., Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Roitt's Essential Immunology (2017) 13th Edition, Wiley-Blackwell Publishers, UK
4. Hyde R. M., Microbiology and Immunology (2012), 3rd Edition. Springer Science & Business Media.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	9	9
CO2	9	9	3	9	9	9
CO3	9	3	3	9	3	9
CO4	3	9	3	3	9	9
CO5	9	3	9	3	3	3
CO6	3	9	9	3	9	9
Weightage	45	36	36	38	42	48

SEMESTER - V		CODE – U21MB11E
Core Course VI: GENETIC ENGINEERING		
CREDITS - 5		HOURS – 5

Objectives:

- To understand the types and significance of restriction enzymes.
- To learn about the specialized functions of vectors and examine recombinants through selection and screening
- To understand methods associated with PCR and their applications.
- To learn the applications of rDNA technology.
- To understand the importance and role of biosafety, bioethical guidelines in rDNA technology

Course Outcomes:

At the completion of the course, the student would be able to:

Cognitive level	COURSE OUTCOMES	Knowledge level
CO1	Define the concepts of restriction enzymes, vectors, gene transfer and role of bio-safety and bioethical guidelines	K1
CO2	Explain the mechanisms of restriction enzymes, vectors, PCR and DNA sequencing methods	K2
CO3	Examine gene transfer and recombinants through selection and screening	K3
CO4	Analyses the significance of genetic engineering tools in gene transfer and its practical applications	K4
CO5	Evaluate the suitable gene transfer technique for the recombinant products.	K5
CO6	Develop the new protocol for improvement of recombinant products for lifelong utilization in the life science field	K6

C2 – Understand C3 – Apply

UNIT I

Overview of genetic engineering and recombinant DNA technology: Concept of restriction and modification - DNA modifying enzymes, Restriction endonucleases, Ligases, Inter-and intra-molecular associations, Linkers, Adaptors.

UNIT II

Gene Transfer: Vectors: Different Kinds of Vectors - Plasmids, Cosmids, Phagemids, Viral vectors, Shuttle vectors, expression vectors, YAC and BAC; Gene Transfer techniques: Transformation, Electroporation, Microinjection and *Agrobacterium* mediated gene transfer; Recombinant Selection and Screening: Marker/Reporter genes, Antibiotic Resistance, Blue-White selection, GFP – GUS; Blotting and Hybridization.

UNIT III

Gene amplification techniques and applications: PCR- Principle, Types, PCR based cloning: cDNA synthesis, cloning and genomic library, Site directed mutagenesis, Applications: RAPD, RFLP, SNPs and DNA fingerprinting; Sequencing: Conventional & NGS.

UNIT IV

Applications of rDNA technology: Production of recombinant proteins - insulin, human growth hormone; Transgenic plants with reference to virus and pest resistances, herbicide tolerance and stress tolerance (cold, heat and salt).

UNIT V

Safety and ethical guidelines in rDNA technology: Biosafety-Identification of hazards, Basic methods for safe handling, transport, and storage of biological and chemical materials ; Bioethics- Ethical implications of GM crops, GMO's, HGP, Human cloning, Designer babies, Biopiracy and Biowarfare.

TEXT BOOKS:

1. Brown T. A. (2001). Gene Cloning, Blackwell Science Publishers.
2. Primrose S. B. (2001). Molecular Biotechnology, Panima Publishing House, New Delhi.
3. Senthil Kumar Sadasivam and Mohammed Jaabir M. S. (2008). IPR, Biosafety and Biotechnology Management, Jasen Publications, India.
4. Goel And Parashar (2013) IPR, Biosafety and Bioethics, Pearson Education, India

REFERENCE BOOKS:

1. Bernard R, Glick and Jack J. Pasternak. (2002). Molecular Biotechnology, Panima Publishing House, New Delhi.
2. Ernst L and Winnacker. (2003). Genes to Clones, Panima Publishing House, New Delhi.
3. Watson J.D, Gilman M, Witkowski and Zoller M. (1992). Recombinant DNA, Scientific American books.
4. Sasson A. Biotechnologies and Development, UNESCO Publications.
5. Rajmohan Joshi (Ed.). 2006. Biosafety and Bioethics. Isha Books, Delhi.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	9	9
CO2	9	9	3	9	9	9
CO3	9	3	3	9	3	9
CO4	3	9	3	3	9	9
CO5	9	3	9	3	3	3
CO6	3	9	9	3	9	9
Weightage	45	36	36	38	42	48

SEMESTER – VI		CODE – U21MB12
Core Course XI: FOOD, DAIRY AND INDUSTRIAL MICROBIOLOGY		
CREDITS – 6		HOURS – 6

Objectives:

- To understand the role of microbes in food and dairy industries.
- To learn food borne diseases and preservation of foods.
- To acquire knowledge on industrially important organisms and types of fermentation.
- To understand and apply downstream processing for product recovery and purification.
- To describe the bioprocess technology derived products.

Course Outcomes:

At the completion of the course, the student would be able to:

Cognitive level	COURSE OUTCOMES	Knowledge level
CO1	List the importance of microbes in food and dairy industry	K1
CO2	Outline the common food borne diseases and methods of food preservation	K2
CO3	Make use of industrially important microbes and gain the knowledge on fermentor and its design	K3
CO4	Analyze the methods of downstream processing in product isolation and purification.	K4
CO5	Elucidate the production of industrial products from microorganisms	K5
CO6	Build the Concepts of good manufacturing practices (GMP)and Hazard analysis and critical control points (HACCP)	K6

C1 – Remember C2- Understand C3 - Apply

Unit I

Importance of food and dairy Microbiology; Types of microorganisms in food spoilage; Source of Contamination; Factors influencing microbial growth in Foods; Dairy and fermented food products: Ice cream, yogurt, acidophilus milk, kumiss, kefir, dahi and cheese; Other fermented foods: idly, dosa, sauerkraut and soy sauce.

Unit II

Food borne diseases; Intoxication and food poisoning; Staphylococcus, Clostridium, *Escherichia coli* and Salmonella infections; Principles, physical methods of food preservation: temperature (low, high, canning, drying), irradiation, chemical methods of food preservation: salt, sugar, organic acids; Concepts of good manufacturing practices (GMP); Hazard analysis and critical control points; Personal hygiene.

Unit III

Isolation and screening of industrially important microbes; Strain improvement: Mutation and Recombination; Media/substrates formulation and optimization; Preservation of industrially important microorganisms; Fermentation: Basic modes of fermentation - Batch, Fed-batch and Continuous; Types of fermentation: surface, submerged and solid state; Fermentor and its types.

Unit IV

Downstream Processing: Objectives and criteria; Intra and extracellular products; Primary separation- Cell disruption [Physical, chemical and enzymatic methods]; Foam separation, flocculation, precipitation methods, filtration, filtration aids and Centrifugation. Secondary

separation: Liquid - liquid extraction, two-phase aqueous extraction, solvent recovery; Membrane based separation (micro & ultra-filtration); Purification: Chromatography; Drying devices, crystallization and whole broth processing.

Unit V

Production of antibiotics: penicillin and streptomycin; Production of organic solvents and acids: ethanol, butanol, acetic acid and citric acid; Production of enzymes: Amylases and proteases; Production of amino acids: L-glutamic acid and L-lysine; Production of Vitamins - vitamin C.

TEXT BOOKS

1. Stainer R.Y, Ingrtham J.L, Wheels M.L and Painter P.R. (1987). General Microbiology, MacMillan.
2. Stanbury P.F, Whitaker A and Hall S.J. (1997). Principles of fermentation technology, Oxford University Press.
3. William C. Frazier, Dennis C. Westhoff, N.M. Vanitha (2017). Food Microbiology, 5th edition, McGraw Hill.

REFERENCE BOOKS

1. Prescott L. M, Harley J. P and Klein D. A. (1999). Microbiology, 4th edition, Mc Graw Hill.
2. Michael L. Shuler, FikretKargi. (2015), Bioprocess Engineering – Basic Concepts, 2nd Ed., Pearson Education India.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	9	9
CO2	9	9	3	9	9	9
CO3	9	3	3	9	3	9
CO4	3	9	3	3	9	9
CO5	9	3	9	3	6	3
CO6	9	3	3	3	9	9
Weightage	48	30	33	38	48	48

SEMESTER – VI		CODE – U21MB13
Core Course XIII: AGRICULTURAL AND ENVIRONMENTAL MICROBIOLOGY		
CREDITS – 6		HOURS - 6

Objective:

- To summarize microbial interactions with emphasis on plant-microbe interactions.
- To learn plant pathogenic diseases caused by microbes and beneficial biopesticides.
- To describe the biogeochemical cycles of major elements of the environment.
- To understand the basic concepts in aero and aquatic microbiology.
- To explain the solid and liquid waste treatment processes and associated terms.

Course Outcomes:

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

Cognitive level	COURSE OUTCOMES	Knowledge level
CO1	Relate the major plant-microbial interactions and recall concepts of biofertilizers.	K1
CO2	Summarize the microbial diseases in agriculture and use of microbial biopesticides	K2
CO3	Categorize the role of microbes in the biogeochemical cycles of elements	K3
CO4	Compare the microbial ecology of air and aquatic environments	K4
CO5	Delineate the treatment process of solid and liquid wastes	K5
CO6	Discuss decomposition of organic matter and Bioremediation	K6

C1 – Remember C2- Understand C3 - Apply

Unit I

Concepts of microbial interactions: positive, negative and neutral (commensalism, synergism, mutualism, competition, parasitism, predation, proto-cooperation, amensalism); Interaction of microbes with plants: Rhizosphere, Phyllosphere, Mycorrhizae; Biofertilizer (*Azolla, Azotobacter, Azospirillum, Rhizobium*) and their advantages; Organic matter decomposition: Composting & Vermicomposting.

Unit II

Plant Pathology: Bacterial diseases - citrus canker, blight of rice; Fungal diseases - potato blight disease, red rot of sugarcane, tikka leaf spot of groundnut; Viral diseases - vein clearing disease of Bhendi, mosaic disease of tobacco and cauliflower; Microbial pesticides: *Bacillus thuringiensis, Pseudomonas fluorescens*, *Trichoderma viride*; and Nuclear Polyhedrosis Virus (NPV).

Unit III

Biogeochemical cycles – Carbon; Nitrogen: nitrogen fixation, nitrification, denitrification; Phosphorus; Sulphur and Iron.

Unit IV

Aeromicrobiology: microbes in air; Assessment of air quality: air sampling techniques; Enumeration of airborne organisms, airborne diseases; Air sanitation.

Aquatic Microbiology: Ecosystems - Freshwater (ponds, lakes, streams), Marine (estuaries, coastal, deep sea).

Unit V

Types of wastes: characterization of solid and liquid wastes; Solid waste treatment – saccharification, composting; Liquid waste treatment: primary, secondary (aerobic, anaerobic – methanogenesis, trickling, activated sludge, oxidation pond) and tertiary treatment; Biological

Oxygen Demand & Chemical Oxygen Demand; Bioremediation of chlorinated hydrocarbons, pesticides, surfactants, metals, nitrates.

TEXT BOOKS

1. Agrios AG. Plant Pathology, Elsevier Academic Press, New Delhi. 2006.
2. Burns RC and Slater JH. Experimental Microbial Ecology – Blackwell Scientific Publications, Oxford, London. 1982.
3. Christon J Hurst. Manual of Environmental Microbiology, 2nd edition. American Society for Microbiology, Washington. 2002.
4. Duncan Mara and Nigel Horen. The Handbook of Water and wastewater Microbiology. Academic press-An imprint of Elsevier. 2003.

REFERENCE BOOKS

1. Gareth M Evans and Judith C Furlong. Environmental Biotechnology-Theory and Application, John Wiley and sons Ltd. 2003.
2. Jogdand, S.N. Environmental Biotechnology, Himalaya Publishing House. New Delhi. 2010. Munn CB. Marine Microbiology- Ecology and Applications. Bios Scientific publishers, New York. 2004.
3. Sambamurty A. Textbook of Plant Pathology, I.K. International Publishing House, New Delhi. 2009.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	9	9
CO2	9	9	3	9	9	9
CO3	9	3	1	9	3	9
CO4	3	9	3	3	9	9
CO5	9	9	9	3	9	3
CO6	9	3	9	3	9	9
Weightage	48	36	29	36	48	48

SEMESTER – VI		CODE – U21MB14
Elective Course III: DIAGNOSTIC MICROBIOLOGY		
Credit-6		HOURS – 6

Objectives:

- To understand infectious diseases and modes of transmission.
- To understand the functional aspects of a diagnostic microbiology lab.
- To familiarize with the concepts of sterilization and biosafety.
- To explain clinical sample collection, transport and rejection.
- To learn the standard biochemical, serological and molecular techniques that are being used in diagnostics

Course Outcomes:

At the completion of the course, the student would be able to:

Cognitive level	COURSE OUTCOMES	Knowledge level
CO1	Recall communicable & non-communicable diseases and choose the diagnostic clinical samples	K1
CO2	Demonstrate the basic organization and standard procedures in a diagnostic microbiology lab	K2
CO3	Apply the standard guidelines for biohazard safety.	K3
CO4	Inspect clinical sample collection, processing and rejection criteria	K4
CO5	Assess and verify appropriate methods for isolation and identification of infectious agents	K5
CO6	Develop serological, immunodiagnostics and molecular diagnostic procedures	K6

C2 – Understand C3 – Apply

UNIT I

Types of diseases: Communicable and Non-communicable infectious diseases; Modes of transmission; Concepts of epidemic, endemic & pandemic; General introduction to types of clinical samples.

UNIT II

Organization of a clinical microbiological laboratory: responsibilities and organization; Organization of Bacteriology, Mycology, Parasitology and Virology sections in a clinical laboratory; Basic facilities required for each section; Standard precautions to follow in a clinical microbiology lab.

UNIT III

Concepts and methods of antisepsis, disinfection and sterilizations; Biological safety measures: gloves, masks, PPE, biosafety levels, biosafety cabinets; Shipping or transport of pathogens and clinical specimens, conditions of transport & handling.

UNIT IV

Types of clinical specimens processed by a clinical microbiology laboratory; Specimen quality; Proper selection, collection, and transport of clinical samples; Contamination of samples; Rejection of samples.

UNIT V

Types of examination of samples: macroscopic, microscopic, and isolation. Concept of Gold standard and tests considered to be Gold standard. Staining techniques: acid-fast staining; Culture media – types and importance; Identification of microorganisms using biochemical tests, serological procedures, immunodiagnostics, molecular diagnostic procedures: PCR, MALDI-TOF, WGS; Antimicrobial agents: antibiotics, antiviral and antiprotozoans; Antimicrobial susceptibility testing.

TEXT BOOK

1. Engelkirk, P.G., Duben-Engelkirk J.L, Laboratory diagnosis of infectious diseases: essentials of diagnostic microbiology, Wolters Kluwer/Lippincott Williams & Wilkins, c2008, ISBN: 9780781797016.
2. Mosby C.V., (2003). Bailey and Scott's Diagnostic Microbiology. 9th edition, St. Louis

REFERENCE BOOK

1. Carey R.B., Bhattacharyya S., Kehl S.C., Matukas L.M., Pentella M.A., Salfinger M., Schuetz A.N. 2018. Practical Guidance for Clinical Microbiology Laboratories: Implementing a Quality Management System in the Medical Microbiology Laboratory. Clin Microbiol Rev. 31(3):e00062-17.

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	9	9
CO2	9	9	3	9	9	9
CO3	9	3	3	9	3	9
CO4	9	9	3	3	9	9
CO5	9	9	9	9	9	9
CO6	9	9	9	3	9	9
Weightage	54	42	31	42	48	54

SEMESTER - VI		CODE – U21MB16E
Core Course XII: BIOINFORMATICS		
CREDITS - 5		HOURS - 5

At the completion of the course, the student would be able to:

Cognitive level	COURSEOUTCOMES	Knowledge Level
CO1	Define basic concepts of bioinformatics, cheminformatics, system biology and find various resources of biological databases	K1
CO2	Explain different formats of biological databases	K2
CO3	Apply different algorithms to compute the similarity and identity of biological data	K3
CO4	Analyze the biological sequences with different tools to infer the evolutionary change.	K4
CO5	Evaluate the biological datasets with various web resources and standalone tools	K5
CO6	Predict the structure and functions of biological data and study their interactions.	K6

UNIT- I

Bioinformatics an overview

History of Bioinformatics – Goal of bioinformatics as a separate discipline – Emerging branches of Bioinformatics: Genomics, Proteomics, Systems Biology, Chemoinformatics–Accessing Bioinformatics resources/databases – NCBI PubMed, EBI, EMBL and ExPASy– Applications and Limitations of Bioinformatics.

UNIT- II

Biological sequence and structure file formats

Genbank, Fasta and Swiss-Prot formats – Sequence Databases : Nucleotide Sequence Databases – GenBank, EMBL, DDBJ – Protein Sequence Databases – SWISS-PROT, TrEMBL, UniProt PIR – ExPASy tools: ProtParam– Genome Databases – GOLD, TIGR – Derived Databases – Prosite, PRODOM, Pfam, PRINTS, CATH, SCOP, DALI – Structure databases – PDB, MMDB, MDL MOL – Protein Structure Visualization Tools: RasMol, Swiss PDB Viewer.

UNIT -III

Sequence analysis

Sequence analysis of biological data – models for sequence analysis and their biological motivation – Basic concepts of sequence similarity, identity and homology – Definitions of homologues, orthologues and paralogues– Sequence Alignment: Dot matrix – Scoring matrices: PAM and BLOSUM Substitution matrices – Alignment scores and gap penalties – Pairwise Sequence Alignments: Local and Global alignment using LALIGN – Database searching tools– BLAST and FASTA algorithms – Various versions of basic BLAST and FASTA.

UNIT -IV

Multiple sequence alignments

Basic concepts of various approaches for MSA – progressive, hierarchical – CLUSTALW and TCOFEE and their application for sequence analysis - Phylogeny: Concept of dendrograms and its interpretation – Phylogenetic analysis – Maximum Parsimony and UPGMA methods – Phylogenetic trees – Rooted and unrooted trees – Phylogeny programs: PHYLIP, PAUP, MEGA.

UNIT -V

GENOMIC DATABASES

GOLD, GDB – Microbial Genome Databases – IMG/M: Integrated Microbial Genomes &Microbiomes - NCBI Genome Databases – Mapviewer – Gene Finding Tools – prokaryotic and eukaryotic tools – Genescan, GLIMMER and MUMMER – Metabolic pathway databases – KEGG – Microarray databases – Informatics solutions for genomics, proteomics, metabolomics and interactomics.

UNIT -VI Current Contours: (For Continuous Internal Assessment only)

Advanced Genome Analysis Techniques - Comparative Genome Analysis - Open Problems about Evolution and Phylogeny - Open Problems about Protein Structure and Function

TEXT BOOK

1. Arthur M. Lesk, Introduction to Bioinformatics, Oxford University Press, New Delhi, 2003.
2. David W. Mount, Bioinformatics – Sequence and Genome analysis, Cold Spring Harbor Laboratory Press, New York, 2001.
3. G. Gibson &S.V.Muse, A Primer of Genome Science, Sinauer Associates, Inc. Publishers, 2002.
4. A. Baxevanis and B.F. Ouellette. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins, Wiley- Interscience, Hoboken, NJ, 2005.
5. A. M.Campbell& L. J. Heyer, Discovering Genomics, Proteomics & Bioinformatics, CSHL Press, 2003.

WEB RESOURCE LINKS

1. www.Bioinformatics.org
2. www.bioinfo.mbb.yale.edu/mbb452a/intro/
3. www.biology.ucsd.edu/others/dsmith/Bioinformatics.html

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	1	1	9	1	3
CO2	9	1	3	9	1	3
CO3	9	1	9	9	1	3
CO4	9	3	9	9	1	9
CO5	9	3	9	9	9	9
CO6	9	9	9	9	3	9
Weightage	54	18	40	54	16	36

SEMESTER -VI		CODE – U21MB15P

Core Course Lab X LAB FOR COURSES IN SEMESTER VI		
CREDITS - 4		**HOURS - 6**

LAB FOR COURSES IN SEMESTER VI

(Group & Individual practical – under STAR College Scheme)

Cognitive level	COURSE OUTCOMES	Knowledge level
CO1	Recall Safety Guidelines in a clinical microbiology lab	K1
CO2	Demonstrate biocontrol activity of biopesticides and association of AMF with plant root	K2
CO3	Identify pathogens by utilizing biochemical characteristics	K3
CO4	Analyze similarity of DNA, protein and gene sequence	K4
CO5	Evaluate and identify nitrogen fixing bacteria and phosphate solubilizing bacteria	K5
CO6	Predict methods for biomass production and amylase production	K6

1. Introduction to parts of the fermentor
2. Mode of fermentation (Batch, Fed-Batch & Continuous)
3. Bacterial Growth Curve (Culture flask and fermentor)
4. Production of Biomass
5. Amylase Production
6. Safety Guidelines to work in a clinical microbiology lab
7. Microscopic examination of clinical samples
8. Isolation of organisms from clinical samples
9. Identification of pathogenic bacteria using biochemical characteristics
10. Retrieval of DNA/Protein/Gene sequence from NCBI and similarity analysis
11. Biomolecule 3D structure prediction
12. Evolutionary analysis – DAMBE, MEGA
13. Molecular and structural visualization of biomolecules through PyMOL
14. Molecular Docking
15. Molecular Simulation
16. Enumeration of total microbial count of soils
17. Isolation and Identification of N fixing bacteria from soil
18. Isolation of Phosphate solubilizing bacteria from soils
19. Identification of AMF- plant root association
20. Biocontrol activity of biopesticides against fungal plant pathogens
21. Isolation and enumeration of airborne organisms- air sanitation (fumigation)
22. Isolation and enumeration of bacteria from marine environment

Co/Po	PO1	PO2	PO3	PO4	PO5	PO6
CO1	9	3	9	9	9	9

CO2	9	9	3	9	9	9
CO3	9	9	3	9	3	9
CO4	9	9	9	9	9	9
CO5	9	9	9	9	9	9
CO6	9	9	9	3	9	9
Weightage	54	48	37	48	48	54

**********END**********