Program Handout for

M.Sc. (Microbiology)

(w.e.f. 2006-07; revised version 2020-2021)

Department of Biosciences
Faculty of Science
Integral University, Lucknow

PROGRAM EDUCATIONAL OBJECTIVES (PEO's)

- To provide in-depth knowledge about core areas of biosciences such as biotechnology, biochemistry and microbiology.
- To make students competent in the field of biosciences and allied areas by providing them hands on experience in basic tools and techniques.
- To instil the ability for research and entrepreneurship in the students along with strong ethics and communication skills.
- To inculcate, facilitate, motivate and promote knowledge and technical skills in core areas of biological sciences including advanced tools and techniques like genomics, proteomics and transcriptomics to young aspirants.
- To equip and motivate the students to pursue higher education and research in reputed institutes at national and international level in the field of science.
- To develop trained human resource in the field of advanced translational research.
- To provide students with an understanding of the role of science in societal development.
- To develop graduates with a strong professional ethics and moral duties that will positively affect their profession, community, society and Nation at large.

PROGRAM OUTCOMES (PO's)

[PO.1] **Critical Thinking:** Take informed actions after identifying the assumptions that frame our thinking and actions, checking out the degree to which these assumptions are accurate and valid, and looking at our ideas and decisions (intellectual, organizational and personal) from different perspectives.

[PO.2] **Effective Communication:** Speak, read, write and listen clearly in person and through electronic media in English and in one Indian language, and make meaning of the world by connecting people, ideas, books, media and technology.

[PO.3] **Social Interaction:** Elicit views of others, mediate disagreements and help reach conclusions in group settings.

[PO.4] **Effective Citizenship:** Demonstrate empathetic social concern and equity centred national development, and the ability to act with an informed awareness of issues and participate in civic life through volunteering.

[PO.5] **Ethics:** Recognize different value systems including your own, understand the moral dimensions of your decisions, and accept responsibility for them.

[PO 6] **Research related skills**: Will develop ability to identify problems, give justifications for solutions by lab investigations & critical analysis by using appropriate research related biological skills.

[PO.7] **Environment and Sustainability:** Understand the issues of environmental contexts and sustainable development.

[PO.8] **Self-directed and Life-long Learning**: Acquire the ability to engage in independent and life-long learning in the broadest context socio-technological changes.

PROGRAM SPECIFIC OUTCOMES (PSO's)

[PSO.1] Get equipped with theoretical and practical understanding of microbiology, its significance, and appreciate the diversity of microbes inhabiting a multitude of habitats.

[PSO.2] To understand fundamental principles of molecular and cellular biology, biochemistry, immunology and bioinformatics.

[PSO.3] Empower the students to acquire technological knowhow and appreciate how microbiology is applied in various applications and manufacture of industrial products.

[PSO.4] Recognize the importance of Bioethics, IPR, entrepreneurship, using statistical tools, Communication and management skills, written and oral reports, scientific publications so as to usher next generation of Indian microbiologists.

INTEGRAL UNIVERSITY LUCKNOW
DEPARTMENT OF BIOSCIENCES

EVALUATION SCHEME (CBCS)
M.Sc. Microbiology Semester-I

Course Code	Course Title	Type of Paper	Periods/Week			Evaluation Scheme				Max. Marks	Credits	Total Credit	Attributes						
			L	T	P	UE	TA	Total	ESE				Employability	Entrepreneurship	Skill development	Gender	Environment & sustainability	Human values	Professional ethics
BS441	General Microbiology	Core	3	1	0	0	20	60	40	100	3:1:0	4	√		√				
BS442	Biophysical Methods	Core	3	1	0	40	20	60	40	100	3:1:0	4	√	√	√				√
BS443	Biomolecules	Core	3	1	0	40	20	60	40	100	3:1:0	4							
BS444	Microbial cytology & genetics	Core	3	1	0	40	20	60	40	100	3:1:0	4							
BS445	Soil and Agricultural Microbiology	Core	3	1	0	40	20	60	40	100	3:1:0	4		√	√		√		
BS446	General Microbiology & Biochemistry Lab	Practical	0	0	12	40	20	60	40	100	0:0:6	6	√		√				√
	Total									600		26							

INTEGRAL UNIVERSITY LUCKNOW
DEPARTMENT OF BIOSCIENCES

EVALUATION SCHEME (CBCS)
M.Sc. Microbiology Semester-II

Course Code	Course Title	Type of Paper	Periods/Week			Evaluation Scheme				Max. Marks	Credits	Total Credit	Attributes						
			L	T	P	UE	TA	Total	ESE				Employability	Entrepreneurship	Skill development	Gender	Environment & sustainability	Human values	Professional ethics
BS451	Microbial Metabolism	Core	3	1	0	40	20	60	40	100	3:1:0	4			√		√		
MT412	Bioinformatics and Biostatistics	Core	3	1	0	40	20	60	40	100	3:1:0	4	√		√				
BS452	Molecular Biology	Core	3	1	0	40	20	60	40	100	3:1:0	4			√				
BS453	Industrial Microbiology & Fermentation Technology	Core	3	1	0	40	20	60	40	100	3:1:0	4	√	√	√				
Elective courses (Any one of the following)		Elective	3	1	0	40	20	60	40	100	3:1:0	4							
BS454	Microbial Diversity																√		
BS455	Mycology and Plant Microbe Interactions																√		
BS412	Enzymology & Enzyme Kinetics												√						
BS456	Applied Microbiology and Bioinformatics Lab	Practical	0	0	12	40	20	60	40	100	0:0:6	6	√	√	√				√
BS419	Educational/Industrial tour									S/U					√				
	Total									600		26							

 # Note: The students of M.Sc. Microbiology have to undergo the educational/Industrial tour in Microbiology based industry/research institution for practical awareness at the end of 2nd semester. [S- satisfactory/ U-unsatisfactory].

INTEGRAL UNIVERSITY LUCKNOW
DEPARTMENT OF BIOSCIENCES

EVALUATION SCHEME (CBCS)
M.Sc. Microbiology Semester-III

Course Code	Course Title	Type of Paper	Periods/Week			Evaluation Scheme				Max. Marks	Credits	Total Credit	Attributes						
			L	T	P	UE	TA	Total	ESE				Employability	Entrepreneurship	Skill development	Gender	Environment & sustainability	Human values	Professional ethics
BS541	Medical Microbiology	Core	3	1	0	40	20	60	40	100	3:1:0	4	√		√				
BS542	Fundamentals of Infection and Immunity	Core	3	1	0	40	20	60	40	100	3:1:0	4	√				√		
BS543	Recombinant DNA Technology	Core	3	1	0	40	20	60	40	100	3:1:0	4	√		√				
BS544	Virology & Biosafety	Core	3	1	0	40	20	60	40	100	3:1:0	4	√						√
BS545	Food & Dairy Microbiology	Core	3	1	0	40	20	60	40	100	3:1:0	4	√	√					
BS546	RDT and Immunology Lab	Practical	0	0	12	40	20	60	40	100	0:0:6	6	√	√	√				
	Total									600		26							

INTEGRAL UNIVERSITY LUCKNOW
DEPARTMENT OF BIOSCIENCES

EVALUATION SCHEME (CBCS)
M.Sc. Microbiology Semester-IV

Course Code	Course Title	Type of Paper	Periods/Week			Evaluation Scheme				Max. Marks	Credits	Total Credit	Attributes						
			L	T	P	UE	TA	Total	ESE				Employability	Entrepreneurship	Skill development	Gender	Environment & sustainability	Human values	Professional ethics
Elective courses (Any one of the following)		Elective	3	1	0	40	20	60	40	100	3:1:0	4							
BS551	Environmental Microbiology																√		
BS552	Commercial & Applied Microbiology												√	√	√				
BS553	Pharmaceutical Biotechnology												√	√	√				
BS514	Seminar	Core	3	1	0	40	20	60	40	100	2	2							
BS515	Project Work*	Practical	0	0	12	40	20	60	40	400	8	8	√		√				
		Total								600		14							

* The Evaluation scheme for the Project Work:

	Course Code	Dissertation	Presentation	Viva/Discussion	Total
Project Work	BS-515	200	100	100	400

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. MB I[st] yr,
Semester: I[st]

BS-441 General Microbiology

L T P C
3 1 0 4

Course Objectives:
The course aims to provide students with an understanding of general microbiology, contribution of microbiology to human life for various daily needs. The knowledge is used in health care for prevention of diseases, diagnosis, sterilization methods and drug production. Further, the knowledge is also extended into food production, production of alcohol, in agriculture, leather industry, etc

Course Outcome (CO)

CO1 Know about the history and development of Microbiology, taxonomy, genetic relationship.

CO2 Know microbial diversity and classification of microbes.

CO3 Know about the distinguished characteristics, morphology and importance of microbes.

CO4 Learn the preparation and use of culture media, Pure culture and cultural characteristics & preservation methods of microbes

CO5 Know about the growth phases – kinetics, asynchronous, synchronous, batch and continuous culture. Get an idea about the various methods of microbial control.

Unit	Course Contents:	Mapped CO	hours
I	**History and development of Microbiology** Theory of abiogenesis & biogenesis, Koch's postulates, River's postulate. Classification and Nomenclature of Microorganisms - concept of kingdom-protista, prokaryote and eukaryotes, Microbial taxonomy, recent criteria used in microbial taxonomy including numerical taxonomy and methods based on genetic relatedness, rRNA based phylogenetic relationship.	**CO.1**	**8**
II	**Introduction to Microbial Diversity** General characteristics and importance of Viruses, Chlamydia, Rickettsia, Mycoplasma, Bacteria and Actinomycetes. Main outline of bacterial classification	**CO.2**	**8**
III	**Distinguished characteristics, general account on morphology, classification and economic importance** of Algae, Protozoa and Fungi. Fungi as Plant Pathogens.	**CO.3**	**8**
IV	**Study of microbes** Preparation and use of culture media, Pure culture and cultural characteristics & preservation methods of microbes. Bacterial Nutrition: Major nutritional types of bacteria, Microbial requirements of C, N, S, P, and microelements, growth factors, etc.	**CO.4**	**8**
V	**Growth and control of microbes** Growth phases – kinetics, asynchronous, synchronous, batch and continuous culture. Factors affecting growth; Measurement of growth. Control of	**CO.5**	**8**

	microorganisms- Physical and Chemical methods		

References

- Gerherdt P, Murray RG, Wood WH. Kreig, NR (1994) Methods for General and Molecular Bacteriology, ASM, Washington DC.
- Madigan MT, Martinko JM, Parker J. (1997) Biology of Microorganisms, Prentice Hall International Inc.
- Mathews CK, Holde KEV. (1996) Biochemistry. The Benjamin/Cummings Publishing Company Inc. NY
- Pelczar Jr. MJ, Chan ECS, Krieg NR (1993). Microbiology – Mc Graw Hill. Inc, New York.
- Stanier RY, Ingraham JL, Wheelis ML, Painter PR (1992). General Microbiology, Mac Millan Education Ltd. London.
- Stryer L. (1995) Biochemistry WH Freeman & Company, New York.

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	3	1				2	2	1	3			
CO2	3	1				-	2	1	3			
CO3	3	1				2		1	3			
CO4	3	1				2		1	3		3	
CO5	3	1				2		1	3		3	
BS441	**3**	**1**				**2**	**2**	**1**	**3**		**2**	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. MB I[st] yr,
Semester: I[st]

BS-442 Biophysical Methods

L T P C
3 1 0 4

Course Objectives:
The objectives of this course are to provide the Students with the understanding of various analytical techniques used in biotechnology based research and industry. The course will acquaint the Students with the various instruments, their configuration and principle of working, operating procedures, data generation and its analysis.

Course Outcome (CO)

CO1	To understand and learn various microscopy techniques used in biotechnology field.
CO2	To understand and learn isolation of cellular fractions-separation, purification of proteins and amino acids, assay techniques for enzymes.
CO3	Demonstrate principle and working of centrifugation and chromatography techniques.
CO4	To learn the principles and applications of molecular techniques in microbiology.
CO5	To learn principles and applications of various biophysical techniques used in the determination of biopolymer structures.

Unit	Course Contents:	Mapped CO	hours
I	.**Microscopy**: Principles and application of light phase contrast, fluorescence, scanning and transmission electron microscopy	**CO.1**	**8**
II	**Isolation of cellular fractions-**separation, purification of proteins and amino acids, assay techniques for enzymes, Methods for lysis of plant, animal and microbial cell. Ultrafiltration, freeze drying and fractional precipitation. Use of detergents in isolation of membrane proteins	**CO.2**	**8**
III	**Centrifugation:** Ultracentrifugation - velocity and buoyant density determination. Density gradient centrifugation, molecular weight determination. Chromatography: Basic principles and applications of ion-exchange, gel filtration, partition, affinity, HPLC and reverse phase chromatography, gas chromatography, TLC, Paper chromatography. Chromatofocussing	**CO.3**	**8**
IV	**Principles and applications of molecular techniques in microbiology**: Electrophoresis: Agarose Gel electrophoresis, PAGE, Isoelectric focusing, capillary electrophoresis. Pulse field gel electrophoresis.RFLP, RAPD, ARDRA, RISA, Western, Northern and southern blotting, FISH, Flourescent activated cell sorting (FACS).	**CO.4**	**8**
V	**Determination of biopolymer structure** (Principles and applications): X-ray diffraction, fluorescence, UV, visible, CD/ORD, ESR, NMR and Mass spectroscopy, Atomic Absorption Spectrophotometer, Plasma emission spectroscopy.	**CO.5**	**8**

References

- Protein Purification by Robert Scopes, Springer Verlag Publication,
- 1982 Tools in Biochemistry David Cooper
- Methods of Protein and Nucleic acid Research, Osterman Vol I – III
- Centrifugation D. Rickwood
- Practical Biochemistry, V th edition, Keth, Wilson and Walker.

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	3	1		3		3		3			3	
CO2	3	1		3		3		3			3	
CO3	3	1		3		3		3			3	
CO4	3	1		3		3		3			3	
CO5	3	1		3		3	1	3			3	
BS442	**3**	**1**		**3**		**3**	**1**	**3**			**3**	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. MB I[st] yr,
Semester: I[st]

BS-443 Biomolecules

L T P C
3 1 0 4

Course Objectives:
The course aims to provide students with an understanding of biomolecules, the basic building blocks of living organisms, focusing on their structural underpinnings, unique properties, biological roles and functions and inter relations. Emphasis will be on the association between structure and function of various biomolecules at a chemical level with a biological perspective

Course Outcome (CO)

CO1	The students will learn about carbohydrates types structure and functions.
CO2	The students will learn about lipids: Definition and classification of lipids.
CO3	The students will learn about proteins and amino acids structure, classification and functions.
CO4	The students will learn about Nucleic acids (DNA and RNA), their composition, structure and functions
CO5	The students will learn about water and fat soluble vitamins functions.

Unit	**Course Contents:**	Mapped CO	hours
I	Carbohydrates: Definition, classification, structure and functions of carbohydrates; Stereoisomerism, aldoses and ketoses; Important classes of monosaccharides, disaccharides, Structural and storage polysaccharides and mucopolysaccharides.	**CO.1**	**8**
II	Lipids: Definition and classification of lipids. Nature of fatty acids. Role of triglycerides in energy storage and phospholipids in membrane formation, sterols, pigments.	**CO.2**	**8**
III	Proteins: Nature of naturally occurring amino acids, Structure and functions of proteins (primary, secondary, tertiary and quaternary structure), Forces responsible for maintenance of protein structure.	**CO.3**	**8**
IV	Nucleic acids: Composition of nucleic acids (ribo and deoxyribonucleic acids); Nucleosides, nucleotides and polynucleotides. Structure and function of DNA and RNA. Types of DNA: A, B and Z DNA, their structure and significance; Physical & biochemical properties of RNA: tRNA, rRNA, mRNA and hnRNA; Primary, secondary, and tertiary structures of RNA	**CO.4**	**8**
V	Vitamins: Fat soluble and water soluble vitamins; elementary ideas about the physiological functions and deficiency diseases; Role of water soluble vitamins as co-enzyme precursor	**CO.5**	**8**

References

- Eckstein F, Lilley DM (1996). Catalytic RNA. Springer Verlag.
- Freidberg EC, Walker GC, Siede W. (1995). DNA Repair and Mutagenesis, ASM Press.
- Freifelder D. (1991). Molecular Biology. Narosa Publishing House.

- Gardener EJ, Simmons MJ, Snustad DP. (1991). Principles of Genetics, John Wiley & Sons.
- Lewin, B. (1997) Genes VI. Oxford University Press.
- Lodish H, Baltimore D, Berk A, Zipursky SL, Matsudaira P, Darnell J. (1995) Molecular Cell
- Biology. Scientific American Books.
- Stryer L (1995). Biochemistry. W.H. Freeman and Company.
- Watson JD, Hopkins NH, Roberts JW, Steitz JA, Weiner AM. (1987) Molecular Biology of the
- Gene. The Benjamin/Cummings Publishing company
- Lehninger's Principles of Biochemistry by D. L. Nelson and M. M. Cox, CBS Publications,
- 2000 Biochemistry by David Rawn

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	3	1				-	-	1		3		
CO2	3	1				-	-	1		3		
CO3	3	1				-	-	1		3		
CO4	3	1				-	-	1		3		
CO5	3	1				-	-	1		3		
BS443	**3**	**1**				**-**	**-**	**1**		**3**		

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

Sc. MB Ist yr,
Semester: Ist

BS-444 Microbial Cytology and Genetics

L T P C
3 1 0 4

Course Objectives:
The course aims to give students a proper understanding of prokaryotic and eukaryotic cell organization, to develop in students the understanding about mechanism and regulation of eukaryotic cell cycle and signal transduction and to explain students about various methods of gene transfer in bacteria.

Course Outcome (CO)

CO1	Develop understanding of prokaryotic cell organization, bacterial cell wall synthesis and details about antibiotics mechanism and development of antibiotic resistance.
CO2	Comprehend the eukaryotic cell organization, membrane function and transport, cytoskeletal elements and genetic organization.
CO3	Have basic knowledge about the cell division in eukaryotes, cell cycle checkpoints and its regulation and various pathways of cell proliferation and apoptosis.
CO4	Understand the basics and mechanism of signal transduction, Quorum sensing and Biofilms.
CO5	Have knowledge about the various methods of gene transfer in bacteria and their mechanisms, Transposons present in prokaryotes and their mechanism of transposition and retrotransposons

Unit	Course Contents:	Mapped CO	hours
I	**Prokaryotic Cell Organization** Bacterial cell wall, Biosynthesis of peptidoglycan, basis of antibiotics, Mode of action of antibiotics, development of resistance, cytoplasmic membrane, ultrastructures of bacterial cell, Endospore, flagella, cell membrane, pili, capsule, prokaryotic genome.	**CO.1**	**8**
II	**Eukaryotic Cell Organization and protein targeting** Membrane biology: Structure, function, membrane protein transport in eukaryotes. Structure and functions of cell organelles, Cytoskeleton (structural proteins-microfilaments, actins, etc), genetic organization (euchromatin, heterochromatin, Nucleosome model), concept of protein targeting.	**CO.2**	**8**
III	**Cell division and cell cycle** Eukaryotic Cell division cycle: Mitosis, Meiosis, Check points, role of cyclins and cyclin dependent kinases in its regulation. Cell proliferation and cell death, apoptosis.	**CO.3**	**8**
IV	**Cell Communication** Basics of signal transduction: Role of calcium, cAMP, G-proteins, inositol phosphates, phospholipases and protein kinases in signal transduction, Quorum sensing, Biofilms and their application.	**CO.4**	**8**

V	**Microbial Genetics** Gene transfer mechanisms in bacteria: Transduction: Generalized, restricted; Transformation: Discovery, competence development, molecular mechanism of DNA uptake; Conjugation: mechanism; mapping; Transposons in prokaryotes: Simple, Composite and complex transposons, Mechanism of transposition; Retrotransposons	**CO.5**	**8**

References

- Alberts Bruce (1985) Molecular Biology of Cell. Garland Pub.
- Conn Eric, Stumpf Paul K., Bruuening George, Doi Roy H., (1987) Outlines of
- Biochemistry Edition , John Wieley and Sons, New Delhi.
- De Robertis E. D. P. and De Robertis E. M. F. (1987), Cellular and
- Molecular Biology Lea and Febiger, Philadelphia.
- Schlegel Hans G. (1995) General Microbiology, Edition 7, CUP, Cambridge.
- Stanier R. Y., Adelberg E. A., Ingraham J. L., (1976) General Microbiology, 4
- Th edition,
- Mac Millan Press, London.

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	3	1				2	1	1		3		
CO2	3	1				2	1	1		3		
CO3	3	1				2	-	1		3		
CO4	3	1				2	-	1		3		
CO5	3	1				2	-	1		3		
BS444	**3**	**1**				**2**	**1**	**1**		**3**		

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

MSc. MB Ist yr,
Semester: Ist

BS-445 Soil and Agricultural Microbiology

L T P C
3 1 0 4

Course Objectives: This paper of microbiology and biochemistry of soil is designed with the objective to provide general introduction of soil and in depth information on soil microbial diversity and the role of microorganisms in biogeochemical cycling of elements like C, N, P and trace elements and soil fertility.

Course Outcome (CO)

CO1	Comprehend the physical, chemical and biological properties of soil and their importance.
CO2	Have in depth knowledge of the role of microorganisms in plant growth particularly in rhizosphere and phyllosphere.
CO3	Develop an understanding of the microbiology and physiology of C and N cycle specifically degradation of native and organic matter and biological nitrogen fixation.
CO4	Have knowledge of microbial transformation of elements as Phosphorus, Iron and Manganese.
CO5	Get insight of the types, production process, application methods and quality control of microbial biofertilizers.

Unit	**Course Contents:**	Mapped CO	hours
I	Soil Microbiology: Structural and textural classes; Physico-chemical and biological properties of soil, soil enzymes, microorganisms and soil fertility. Methods used in soil chemistry and microbiological studies.	**CO.1**	**8**
II	Rhizosphere and Phyllosphere – Rhizosphere and Phyllosphere microorganisms, Rhizosphere effect, root exudates, influence of rhizosphere on crop productivity, plant growth promotingbacteria, biological control within microbial communities of rhizosphere, role of antibiotics and siderophore in biocontrol of plant pathogens, Induced resistance: Phytoalexins	**CO.2**	**8**
III	Biogeochemical cycles: Carbon cycle: aerobic and anaerobic decomposition of native and added organic matter, lignolytic and cellulolytic microorganisms. Nitrogen cycle: symbiotic and asymbiotic nitrogen fixation, Ammonification, nitrification, denitrification.	**CO.3**	**8**
IV	Microbial transformation of Phosphorus, sulphur and micronutrients– Phosphorus cycle, mineralization of inorganic phosphates. Microbial transformation of Iron and Manganese.Microbial transformation of sulphur- Sulphur cycle, sulphur oxidizing and reducing microorganisms (Thiobacillus and Desulfovibrio).	**CO.4**	**8**
V	Biofertilizes: Definition and status of biofertilizer, types of biofertilizers. Nitrogenous and phosphatic biofertilizers - Rhizobium, Azotobacter, Azospirillum, Frankia, Vesicular Arbuscular Mycorrhiza and PSB/PSF Technologies for the production of biofertilizers. Methods of inoculation on seed and in soil. Quality control of biofertilizers.	**CO.5**	**8**

References

- Agricultural Microbiology – Rangaswami.
- Soil Microbiology – Alxander Martin.
- Soil and soil microorganisms – Subbarao

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	3	1					2	1	3		2	
CO2	3	1				1	2	1	3		1	
CO3	3	1					2	1	3	2		
CO4	3	1					2	1	3	2		
CO5	3	1			1	2	2	1	2		3	
BS445	**3**	**1**			**1**		**2**	**1**	**3**	**1**	**2**	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. MB I[st] yr,
Semester: I[st]

BS-446 General Microbiology Lab

L T P C
0 0 12 6

Course Objectives:
This course has been designed to provide the students a practical hand on various biochemical assays that are being used on regular basis in the biochemistry labs i.e. tests for carbohydrates, proteins, amino acids, cholesterol, DNA and RNA. In addition, student will also perform microbiology experiments i.e. detection of gram positive and negative bacteria, preparation on culture media sterilization and growth pattern in bacteria etc.

Course Outcome (CO)

CO1	Know the principles and instruments used in microbiology and various techniques.
CO2	Students will learn pure culture techniques and know how to enumerate microbes from soil samples
CO3	Know how to perform Gram staining, spore staining for bacteria, and fungal staining followed by microscopic examination and biochemical identification of bacteria
CO4	Students will know how to determine bacterial motility and isolate Rhizobium from nodules
CO5	Students will also be able to perform biochemical estimations of macromolecules in a given sample

S.No.	Experiments:	Mapped CO
1	General instructions, Microbiology laboratory and its discipline.	**CO.1**
2	Handling of microscopes, Calibration and measurement of microscopic objects.	**CO.1**
3	Cleaning of glassware and sterilization. Preparation and use of glassware cleaning solutions, sterilization.	**CO.1**
4	Pure culture techniques: serial dilution, pour plate, spread plate, streak plate methods	**CO.2**
5	Enumeration of bacteria from soil samples.	**CO.2**
6	Enumeration of fungi from soil samples.	**CO.2**
7	Enumeration of actinomycetes from soil samples.	**CO.2**
8	Culture and microscopic examination of bacteria by staining methods - Gram‘s, capsule and spore staining.	**CO.3**
9	Culture and microscopic examination of fungi by Lacto-phenol cotton blue staining.	**CO.3**
10	Identification techniques: morphological and biochemical identification of bacteria using Bergey‘s Manual of Determinative Biology	**CO.3**
11	Motility of bacteria.	**CO.4**
12	Isolation of Rhizobium from nodules	**CO.4**
13	Estimation of carbohydrates	**CO.5**

14	Estimation of protein	**CO.5**
15	Estimation of DNA	**CO.5**
16	Estimation of RNA	**CO.5**
17	Estimation of chlorophyll	**CO.5**

References

- Cappuccino, J. C. and Sherman, N. (1992). Microbiology: A laboratory manual, Addison
- Wesley Pub. Co
- Benson HJ (1994). Microbiological Applications, WmC Brown Publishers, Oxford.
- Collins C.H, Lyne P.M, (1985). Microbiological methods. Butterworths, London.
- Rhodes P.M, Stanbury P.F. Applied Microbial Physiology - A practical approach. IRL
- Press, Oxford University Press, Oxford.
- Wilson K, Walker J. (1995) Practical Biochemistry Principles and Techniques, Cambridge
- University Press
- K.R. Aneja
- Bergey‘s Manual of Determinative Bacteriology

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	3	3	1			3		3	1		3	2
CO2	3	3	1			3	1	3	3		3	2
CO3	3	3	1			3		3	3		3	2
CO4	3	3	1			3		3	3		3	2
CO5	3	3	1			3		3		3	3	2
BS446	**3**	**3**	**1**			**3**		**3**	**2**	**1**	**3**	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. MB Ist yr,
Semester: IInd

BS-451 Microbial Metabolism

L T P C
3 1 0 4

Course Objectives:
On completion of this course, students will be able to develop an understanding of:catabolism, anabolism, regulation of metabolism and pathway analysis. It also gives understanding of how enzymes and metabolites in living system work to produce energy and synthesizing different biomolecules. The course also imparts comprehensive knowledge about biochemical pathways involved in intermediary metabolism of carbohydrate, protein, lipid and nucleic acid.

Course Outcome (CO)

CO1	Understand the concept of enzymes and enzyme kinetics
CO2	Comprehend the carbohydrate metabolism, significance of glycolysis and ETC
CO3	Acquire knowledge about the metabolism of lipids, amino acids and nucleic acids.
CO4	Understand the basics of microbial degradation of Xenobiotics and Fermentation: Special pathways for primary attack on organic compounds by microorganisms
CO5	Have knowledge about the Nitrogen metabolism and Biological nitrogen fixation

Unit	Course Contents:	Mapped CO	hours
I	**Enzymes** Classification, properties and factors influencing enzyme activity, co-enzymes, prosthetic group and co-factors, Lock & key hypothesis, induced fit hypothesis, Enzyme kinetics: Michelis Menten equation, Lineweaver-Burk plot, Enzyme inhibition, Allosteric enzymes	**CO.1**	**8**
II	**Aerobic and anaerobic metabolism in bacteria** Aerobic and anaerobic metabolism in bacteria - role of ATP, reducing powers and Biochemistry of catabolic reactions in aerobic heterotrophs: Glycolysis, hexose monophosphate shunt and Entner doudoroff pathways, TCA cycle, Role of glyoxylate cycle in acetic acid oxidation. Electron transport chain and oxidative phosphorylation, Gluconeogenesis	**CO.2**	**8**
III	**Metabolism of lipids, amino acids and Nucleic acids** Oxidation of fatty acid (beta-oxidation) and its biosynthesis. Metabolism of amino acids. Biosynthesis and degradation of nucleotides	**CO.3**	**8**
IV	**Microbial degradation of Xenobiotics and Fermentation** Special pathways for primary attack on organic compounds by microorganisms, Catabolic reactions of anaerobic chemohetrotrophs, Anaerobic respiration and fermentation. Autotrophic nutrition of microorganisms. Bacterial photosynthesis	**CO.4**	**8**
V	**Nitrogen metabolism** Biological nitrogen fixation: nitrogenase enzymes, structure and properties, ‗nif' gene: regulation and functions. Physiology and biochemistry of nitrogen fixation, denitrification, nitrate and nitrite reduction, sulphate and sulphur reduction, H_2S	**CO.5**	**8**

	formation, deamination and transamination. Utilization of various nitrogen sources (ammonia, urea, nitrate, amino acids) by bacteria.		

References

- Brock —Biology of Microorganisms‖
- Brown, T.A. —Gene cloning: An introduction‖
- Freifelder, DM —Molecular Biology‖.
- Lehninger —Biochemistry‖
- Lewin —Genes‖.
- Old & Primrose —Principles of Gene
- Manipulation‖ Pelczar —Introduction of
- Micobiologu‖ Stryer —Biochemistry‖

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	3	1				-	-	1		3		
CO2	3	1				-	-	1	3	3		
CO3	3	1				-	-	1		3		
CO4	3	1				-	1	1	3	3		
CO5	3	1				-	2	1	3	3		
BS451	**3**	**1**				**-**	**-**	**1**	**2**	**3**		

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. MB I[st] yr,
Semester: II[nd]

MT-412 Bioinformatics and Biostatistics

L T P C
3 1 0 4

Course Objectives:
The objective of this course is to understand the basics of the computer bioinformatics and statistical analysis

Course Outcome (CO)

CO.1 To understand the Basics of computers.

CO.2 To understand the biological data formats

CO.3 To understand the mechanisms of sequence analysis.

CO.4 To understand the biostatistics

CO.5 To understand the correlation analysis

Unit	Course Contents:	Mapped CO	hours
I	**Basics of computers** Block diagram of computer, input and output devices, storage devices, operating systems – DOS, Windows, Linux. Basics of networking and their types, topologies, INTERNET: TCP/IP, World Wide Web, e-mail etc.	**CO.1**	**8**
II	**Biological data file formats** *.FASTA, *.PIR, *.GDE, *.PDB, Alignment files (*.ALN) etc. Search engines: ENTREZ, DBGET, SRS etc. Primary nucleotide sequence atabases: Genbank, EMBL, DDBJ; Primary Protein sequence databases: SwissProt, Protein information resources, TREMBL. Etc. Secondary databases: PROSITE, PRINTS, BLOCKS, PFAM.; Microbiology DATABASES: ICTV, Animal Virus Information System (AVIS).	**CO.2**	**8**
III	**Sequence analysis –Pair wise Sequence Alignment** Needleman wunsch, Smith Watermann algorithms, Sequence similarity search programs – BLAST and FASTA. Substitution matrices: PAM, BLOSSUM. Multiple sequence alignments: Center Star method, Clustal, PRAS. Phylogenetic analysis: Character based (Parsimony) and distance based methods (UPGMA, neighbor joining), Protein structure prediction: Homology modeling, Primer Designing, Multi dimentional protein identification technology – identification using database.	**CO.3**	**8**
IV	**Biostatistics** Measures of central tendency – mean (arithmetic, harmonic & geometric) median and mode; Measures of dispersion- range, quartile deviation, mean deviation and standard deviation. Coefficient of variation.	**CO.4**	**8**
V	**Correlation analysis** Positive and negative correlation, Karl Pearson‘s coefficient of correlation, Spearman‘s rank correlation. Regression analysis: regression line Y on X and X on Y, angle between two regression lines. Test of significance: null and alternative hypothesis, level of significance, Z-test, Student_t‘-test, Chi-square test for goodness of fit and independence of attributes.	**CO.5**	**8**

References

- Developing Bioinformatics Computer Skills: Cynthia Gibas & Per Jambeck – 2001 –Shroff Bioinformatics Basics: Applications in Biological Science and Medicine – 2002 - HH Rashidi & LK Buehler, CRC Press, London Bioinformatics: Sequence, structure and databanks – 2000 - Des Higgins & Willie Taylor – Bioinformatics: A practical guide to the analysis of genes and proteins – 2001 - AD Baxevanis & BFF Ouellette – Wiley Interscience – New York
- Biostatistics (1996) Arora PN & Malhon PK – Imalaya Publishing House, Mumbai. Primer of Biostatistics – Stanton A & Clantz – The McGraw Hill Inc., New York.

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	3	1				2		1		3	2	
CO2	3	1				2		1		3	2	
CO3	3	1				2		1		3	2	
CO4	3	1				2		1				3
CO5	3	1				3		1				3
MT412	**3**	**1**				**2**		**1**		**2**	**2**	**2**

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. MB I[st] yr,
Semester: II[nd]

BS-452 Molecular Biology

L T P C
3 1 0 4

Course Objectives:
To develop in students the understanding about advanced techniques used in molecular biology and biotechnology and their application

Course Outcome (CO)

CO.1 Comprehend the experiments that prove DNA is a genetic material, DNA replication and its regulation in prokaryotes

CO.2 Develop and understand the concept of transcription in prokaryotes and its regulation

CO.3 Have basic knowledge about the Translation in prokaryotes and its regulation

CO.4 Understand the basics of Post translational and post-transcriptional mechanisms and their regulation.

CO.5 Have knowledge about the regulation of gene expression in prokaryotes using Lac operon and various DNA damage repair mechanisms.

Unit	Course Contents:	Mapped CO	hours
I	**Nucleic acid as information carriers and Replication** Griffith, Avery, McLeod and McCarty, Hershey and Chase experiment; Possible modes of replication: Meselson and Stahl experiment; Prokaryotic DNA replication; Origin of replication; Roles, properties and mechanism of action of DnaA, Helicase, HD protein, Primase, DNA gyrase, Topoisomerase, DNA Polymerase, DNA ligase; Fidelity and regulation of replication; or Rolling circle replication in X174.	**CO.1**	**8**
II	**Transcription in prokaryotes** Prokaryotic promoter; RNA polymerase: X-Ray crystallographic structure, Subunits, Types of subunit; Recognition of promoter; Binding and initiation sites; Melting of DNA; Abortive initiations; Promoter clearance; Rho dependent and Rho independent termination of transcription; Sigma cycle; Reverse transcription.	**CO.2**	**8**
III	**Translation in prokaryotes** Adapter role of tRNA, Evidences for a triplet code; Properties of Genetic code; Codon family and Codon pairs; Significance of Isoacceptor tRNAs and Wobble hypothesis; A, P and E sites of ribosome; Ribosome binding site; Formation of initiation complex; Transpeptidation and Translocation; Ribosome cycle; Roles of Initiation factors, Elongation factors, Release factors, Aminoacyl tRNA synthetase, tRNA, rRNA, GTP, Peptidyl transferase site and Factor binding site of ribosomes in translation.	**CO.3**	**8**
IV	**Post - transcriptional / Cotranscriptional processing of rRNA, mRNA, tRNA** Addition of 5` cap and 3‘ Poly A tail in mRNA, RNA splicing - Self splicing and Spliceosome mediated splicing, Cutting events or action of ribonucleases, Covalent modifications, RNA editing. Post - translational processing: Basics of Protein	**CO.4**	**8**

	folding, Intein splicing, Chemical modification, Proteolytic cleavage, Zymogen activation; Polycistronic and monocistronic.		
V	**Regulation of gene expression, mutation and DNA repair** Concept of operon: Lac and Trp operons, Eukaryotic gene expression, Significance of repressor, Attenuation; histone modifications, Mutation: Types of mutations, DNA repair mechanisms: Photoreactivation, Base excision repair, Nucleotide excision repair, Transcription coupled repair, Mismatch repair, Recombination repair, Translesion DNA synthesis; Y-family DNA Polymerases.	**CO.5**	**8**

References

- Lewin B. (2000). Genes VII. Oxford University press
- Lodish H, Baltimore D, Berk A, Zipursky SL, Darnell J. (1995). Molecular cell biology.
- Watson JD, Hopkins NH, Roberts JW, Steitz JA, Weiner AM. (1987). Molecular biology of
- the gene.
- Brown T A (1995) Essential molecular biology, vol. I, A practical approach, IRL press, Oxford

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	3	1				-	1	1		3		
CO2	3	1				1	-	1		3		
CO3	3	1				1	-	1		3		
CO4	3	1				1	-	1		3		
CO5	3	1				1	-	1		3		
BS452	**3**	**1**				**1**	**1**	**1**		**3**		

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

M.Sc. MB I[st] yr, Semester: II[nd]

BS-453 Industrial Microbiology & Fermentation Technology

L	T	P	C
3	1	0	4

Course Objectives:

On completion of this course, students will be able to develop an understanding of Industrial microbiology & fermentation contains improved biochemical or physiological fermentation are mainly carried out by fungi and bacteria on large scale to produce commercial products. The main objective of industrial fermentation is to produce highest quality and quantity of particles produce by combining.

Course Outcome (CO)

CO.1 Know the basics of fermentation technology.

CO.2 Have insight to the general design of fermenter, media and the process of fermentation

CO.3 Understand the relation between growth and product formation, optimization of fermentation process and DSP.

CO.4 Have knowledge of how microbes are used for production of important industrial products.

CO.5 Have basic knowledge of intellectual property rights specially patents.

Unit	Course Contents:	Mapped CO	hours
I	**Introduction to Industrial Microbiology** Basic principles of fermentation technology, Isolation, screening and maintenance of industrially important strains, Types of fermentations, Growth Kinetics of microbes during fermentation (Batch and continuous). Fermentation media-Types of fermentation media, sources of carbon, nitrogen, trace elements, growth factors, precursors, buffers, antifoam agents, sterilization of media.	**CO.1**	**8**
II	**General design of fermenter** General design of fermenter, concept and importance of gas exchange and mass transfer and scale-up in microbial fermentation. Processes of fermentation. Basic concept of cell and enzyme immobilization and reactors used for immobilized enzymes	**CO.2**	**8**
III	**Growth and product formation** Growth and product formation: Definition of primary and secondary metabolites, and their control, screening of new metabolites and isolation approaches of unidentified microbial products. Overproduction of industrially important metabolites by strain improvement; Product recovery and techniques involved in downstream processing	**CO.3**	**8**
IV	**Microbial production of industrially important products** A brief idea about the products obtained from microbes, commercial production of citric acid and glutamic acid, antibiotics (as penicillin), solvents (ethanol), vitamins (B12), enzymes (Protease). Production of single cell protein- Microorganisms and substrates used, techniques of production, merits and demerits of single cell protein.	**CO.4**	**8**

V	**Intellectual property rights** Introduction to intellectual property rights; Intellectual property laws; significance of IPR. Forms of IPR like patent, design copyright and trademark. Requirement of a patentable novelty; Issues related to IPR protection of software and database; IPR protection of life forms. Obtaining patent; Invention step and prior art and state of art procedure; Detailed information on patenting biological products and biodiversity. Trade related aspects of Intellectual Property Rights and Budapest treaty.	**CO.5**	**8**

References

- Industrial Microbiology by L.E Casida , John Wiley and sons INC.
- Prescott and Dunn,s Industral microbiology, 4th edition (1982) by Gerald Reed.
- Food processing:Biotechnological applications by S.S Marwaha and
- Microbial technology vol.I & II by H.J.Peppler & D.Perlman.Academic press INC.
- Principles of fermentation technology by P. Stanbury & Allan Whitekar, Pergamon
- Press Industrial microbiology by Cruger and Cruger

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	**3**	**1**				**1**	**1**	**1**	3			
CO2	**3**	**1**				**1**		**1**			3	
CO3	**3**	**1**				**1**		**1**	1		3	
CO4	**3**	**1**				**2**	**1**	**1**	1		3	
CO5	**3**	**1**		**3**	**3**	**2**	**2**	**1**				3
BS453	**3**	**1**		**3**	**3**	**2**	**2**	**1**	**1**		**2**	**1**

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. MB I[st] yr,
Semester: II[nd]

BS-454 Microbial Diversity

L T P C
3 1 0 4

Course Objectives:
On completion of this course, students will be able to develop an understanding of microbial diversity

Course Outcome (CO)

CO1 Microbial ecology – concepts of Niche, habitat, ecosystem etc.

CO2 Microbial interactions: symbiosis, synergism, fungal and algal association with plants.

CO3 General characteristic of purple and green sulphur bacteria, Cyanobacteria and Prochlorales. BGA in agriculture.

CO4 Methanogenic Archeobacteria—General characteristics. Bioluminescent and nitrogenfixing bacteria. Magnetotactic bacteria Microorganisms in prospecting of oils Extremophiles- Acidophilic, alkalophilic, psychrophilic, thermophilic and halophilic microorganisms

CO5 Microbes of toxic environments; Biodeterioration-concept, biodeterioration of wood, stonework, pharmaceutical products, rubber, plastic, paints, lubricants, cosmetics, control of biodeterioration

Unit	Course Contents:	Mapped CO	hours
I	**Microbial ecology** Concept of habitat and ecological niches, Ecosystem, Energy flow, food chain, food web, biotic community concept, Microbial succession, adaptation and natural selection of microbial population.	**CO.1**	**8**
II	**Microbial interactions** Symbiosis, Synergism, Commensalism, Ammensalism, Predation and Parasitism, Mycorrhizal associations-structure, characteristics and their role in Agriculture and Forestry, Algal association with other microorganisms and plants	**CO.2**	**8**
III	**Photosynthetic microbes** Anoxygenic photosynthetic microbes General characteristic of purple and green sulphur bacteria. Oxygenic photosynthetic microbes- General characteristics of Cyanobacteria and Prochlorales; Role of blue green algae (BGA) in agriculture	**CO.3**	**8**
IV	**Archeobacteria** Methanogenic Archeobacteria—General characteristics. Bioluminescent and nitrogenfixing bacteria- A high energy spending bacteria. Magnetotactic bacteria Microorganisms in prospecting of oils Extremophiles- Acidophilic, alkalophilic, psychrophilic, thermophilic and halophilic microorganisms.	**CO.4**	**8**
V	**Microbes of toxic environments and Biodeterioration** Acid mine drainage, coal desulphurisation, waste containing cyanides, xenobiotics, pesticides and chemicals, heavy metals, hydrocarbons & radio isotopic materials Concept of autotrophy – an example of extreme synthesis Biodeterioration-concept, biodeterioration of wood, stonework, pharmaceutical products, rubber, plastic,	**CO.5**	**8**

	paints, lubricants, cosmetics, control of biodeterioration		

References

- Extremophiles-(2000) By B.N.Johari Springer Verlag,New York.
- Microbial diversity (1999) by D.Colwd Academic press.
- Bergy‘s Manual of Systematic Bacteriology (1984).Vols.I and III .Williams
- and Wilkins, Baltimore Academic press
- Microbial life in extreme environments (1978) by D.S.Kushner Academic press Inc. NY.
- Microbial ecology (1979) by J.M.Lynch and N.J.Poole. Blackwell Publications, Oxford.
- Brock biology of microorganisms (2000). 9th eds.by Madigan, Martinko and Jack parker.

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	**3**	**1**					**3**	**2**	3			
CO2	**3**	**1**					**3**	**2**	3			
CO3	**3**	**1**					**3**	**2**	3			
CO4	**3**	**1**					**3**	**2**	3			
CO5	**3**	**1**					**3**	**2**	3			
BS454	**3**	**1**					**3**	**2**	**3**			

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. MB I[st] yr, Semester: II[nd]

BS-455 Mycology and Plant Microbe Interactions

L T P C
3 1 0 4

Course Objectives:
The objective of this course is to develop an understanding of the fungi lichen and interaction of microbes to plant and to understand different plant diseases caused by fungi

Course Outcome (CO)

CO1	Have insight into the general characters of fungi, their nutritional types and genetic variation
CO2	Have knowledge of the general classification and main groups of fungi.
CO3	Comprehend the economic importance of fungi, the biology and importance of lichens and the role of saprotrophs in ecosystems.
CO4	have basic understanding of the complex plant microbe nteraction in Rhizosphere and phyllosphere and know the microorganisms acting as biofertilizers and biopesticides or causing diseases and understand the factors influencing plant diseases
CO5	have knowledge of some common Plant Diseases: including their epidemiology, symptoms,

Unit	Course Contents:	Mapped CO	hours
I	**Fungi** Historical account; General characters of fungi with special reference to thallus organization and reproduction in fungi. Nutritional types of fungi: biotrophs, hemibiotrophs, symbionts and necrotrophs and life cycle in fungi. Genetic variation in fungi- heterocaryosis and parasexual cycle and their significance. Sex hormones in fungi.	**CO.1**	**8**
II	**Genral classification of fungi** Study of the following main groups of fungi: Myxomycota with special reference to Stemonitis; Plasmodiophormycetes with special refrence to Plasmodiophora; Oomycetes with special reference to Pythium.; Zygomycotina with special reference to Zygorhynchus; Ascomycotina with special reference to Yeasts, Protomyces, Aspergillus, Taphrina; Basidiomycotina with special reference to Puccinia, Agaricus; Deuteromycotina with special reference to Alternaria.	**CO.2**	**8**
III	**Economic importance of fungi** Lichens: types, biology and physiology of lichen thallus, economic importance of lichens; Mycorhiza. Beneficial uses of fungi, industrial production of enzymes and penicillin. Edible Mushrooms. Fungi as animal parasites, mycoses of vertebratestypes and symptoms. Insect fungus association. Role of saprotrophs in ecosystems.	**CO.3**	**8**
IV	**Plant Microbe interaction** Interaction in Rhizosphere and phyllosphere. Plant growth promotion and its mechanisms, Biofertilizers and biopesticides. Plant pathogens: Koch‘s postulates. Classification of plant diseases. Dissemination of phytopathogens. Causal agents	**CO.4**	**8**

	of plant diseases. General symptoms of plant diseases. Factors influencing infection, colonization and development of symptoms. Specialization of parasitism, pathogenesis: role of enzymes and toxins in pathogenesis. Genetics of host-pathogen interaction. Defense mechanism in host: effect of infection on host physiology. Control of plant pathogens (plant quarantine; Cultural, Physical, chemical & biological methods of control).		
V	**Plant Diseases** Epidemiology, symptoms, etiology, perennation and control of following diseases: Damping off of seedling and fruit rot- Pythium ; Stem gall of coriander-Protomyces macrospores; Peach leaf curl- Taphrina deformans ; Rust of wheat- Puccinia recondite ; Covered smut of barley-Ustilago hordei; Leaf spot and shot holes-Alternaria spp. Citrus canker; Tobacco mosaic disease; Root knot of vegetables-Meloidogyne ; Abiotic/Non pathogenic diseases – Black tip of mango ; Mycotoxins and storage diseases.	**CO.5**	**8**

References

- Aneja, K.R. & Mehrotra, R.S. (2011). Fungal Diversity & Biotechnology. New Age International Publishers, New Delhi.
- Alexopoulos, C. J., Mims, C.W. and Blackwell, M. (1996). Introductory Mycology.4 Th edition John Wiley & Sons, USA.
- Mehrotra, R.S. and Aneja, K.R. (2010). Introduction to Mycology. Wiley Eastern Ltd. New Delhi. Moore –Landcker , E.(1996).Fundamentals of the Fungi. Prentice Hall
- Agriose, G.N. 2005, Plant Pathology,5 TH edition Academic Press, Inc., Ainsworth, G.C. and Sussman, A.A. (Eds).
- J.W. Deacon (1997) Modern Mycology (Basic Microbiology) 3 rd Ed. Wiley Blackwell

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	**3**	**1**					**3**	**1**	3			
CO2	**3**	**1**					**3**	**1**	3			
CO3	**3**	**1**				**2**	**3**	**1**	3			
CO4	**3**	**1**			**1**	**1**	**3**	**1**	3			
CO5	**3**	**1**			**1**	**1**	**3**	**1**	3			
BS455	**3**	**1**			**1**	**2**	**3**	**1**	**3**			

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. MB I[st] yr,
Semester: II[nd]

BS-412 Enzymology & Enzyme Kinetics

L T P C
3 1 0 4

Course Objectives:
This course has been designed to teach the student majoring in science all the major aspects of the study of enzymes. The course focuses on the theories of enzyme kinetics, the mechanisms of enzyme catalysis, and immobilization of enzyme

Course Outcome (CO)

CO1 To understand the general properties of enzymes and their classification & nomenclature
CO2 To understand the theories of enzyme kinetics
CO3 To understand the mechanisms of enzyme catalysis and enzyme inhibition & activation
CO4 To understand the Multisubstrate enzyme kinetics
CO5 To understand the enzyme Immobilization and its clinical & industrial use

Unit	Course Contents:	Mapped CO	hours
I	Classification and nomenclature of enzymes. General properties of enzymes. Mechanism of enzyme action: Chymotrypsin, ribonuclease, activation of transition metal cation, activation by alkaline earth metal cation, nicotinamide nucleotide, flavin nucleotide and adenosine phosphate	**CO.1**	**8**
II	Michaelis-Menten initial rate equation based on equilibrium assumption, Briggs-Haldane steady state approach, integrated form of the Michaelis equation, methods for the determination of Km and Vmax normalized initial rate equation and normalized curves, Haldane relationship	**CO.2**	**8**
III	Effect of enzymes concentration, pH and temperature on kinetics of enzyme reactions. Enzyme inhibition and activation: Types of reversible inhibitors, qualitative analysis of data, derivation of equations for different types of inhibitions, determination of inhibitor constant, determination of activator constant.	**CO.3**	**8**
IV	Multisubstrate enzyme kinetics: random bi-bi, and ping pong reactions. Intracellular localization of enzymes, purification of enzymes and tests for homogeneity	**CO.4**	**8**
V	Immobilization; kinetics of immobilized systems. Isozymes. Allosteric enzymes. Industrial and clinical scope of enzymes.	**CO.5**	**8**

References

- Lehninger, AL —Principles of Biochemistry‖
- Lubert Stryer —Biochemistry‖
- Voet & Voet —Biochemistry‖
- Shuler —Bioprocess Engineering‖
- Alan Fersht —Enzyme Structure and Mechanism‖
- David S. Sigman, Paul S. Sigman —The Enzymes: Mechanisms of Catalysis‖

- Palmer —Enzymesl
- Dixon & Webb —Enzymes

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	3	1				2		1		3		
CO2	3	1				2		1		3		
CO3	3	1				2		1		3		
CO4	3	1				2		1		3		
CO5	3	1				3		1		3	3	
BS417	**3**	**1**				**3**	**-**	**1**		**3**	**1**	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. MB I[st] yr, Semester: II[nd]

BS-456 Applied Microbiology and Bioinformatics Lab

L T P C
0 0 12 6

Course Objectives:

To understand about the various chemical and physical factors involved in bacterial growth along with Enumeration of phyllosphere/rhizosphere microbial flora,detection of extracellular microbial enzymes and antibiotic sensitivity and/or toxicity testing using bacterial system. Basics of computers – basic commands – file creation, copying, moving & deleting in DOS & Windows. will also be performed along with the understanding of various biological databases. The provides knowledge and practicing of sequence analysis, multiple sequence analysis and gene prediction

Course Outcome (CO)

CO1	Measurement of bacterial growth/growth curve, Effect of physical and chemical factors on the growth of bacteria: temperature, pH, and salts and Enumeration of phyllosphere/rhizosphere microbial flora and Enumeration/Isolation of PSB/PSF
CO2	Detection of extracellular microbial enzyme: Beta lactamases, Testing for antibiotic sensitivity and/or toxicity using bacterial system, Determination of MIC values (tube dilution and spot plate method), Screening for antibiotic producing microbes and Microbiological examination of milk and milk products
CO3	Microbiological quality testing of milk (MBRT test) and Microbial examination of industrial waste water/sewage.
CO4	Understanding basics of computers – basic commands – file creation, copying, moving & deleting in DOS & Windows. Internet - Using browsers – search engines and understanding use of various biological databases-GENBANK, EMBL, Swissprot – Protein Data Bank.
CO5	Performing different types of sequence analysis queries in BLAST and FASTA. (Homology search), Multiple sequence alignments (Clustal) and Phylogenetic Analysis. (Phylip or Clustal) and Gene Prediction.

S.No.	**Experiments:**	Mapped CO
1	Measurement of bacterial growth/growth curve, Effect of physical and chemical factors on the growth of bacteria: temperature, pH, and salts	**CO.1**
2	Enumeration of phyllosphere/rhizosphere microbial flora. Enumeration/Isolation of PSB/PSF	**CO.1**
3	Detection of extracellular microbial enzyme: Beta lactamases, Testing for antibiotic sensitivity and/or toxicity using bacterial system, Determination of MIC values (tube dilution and spot plate method)	**CO.2**
4	Screening for antibiotic producing microbes	**CO.2**
5	Microbiological examination of milk and milk products, Microbiological quality testing of milk (MBRT test)	**CO.3**
6	Microbial examination of industrial waste water/sewage.	**CO.3**
7	Basics of computers – basic commands – file creation, copying, moving & deleting in DOS & Windows. Internet - Using browsers – search engines.	**CO.4**

8	Using biological databases – GENBANK, EMBL, Swissprot – Protein Data Bank	**CO.4**
9	Different types of sequence analysis queries in BLAST and FASTA. (Homology search)	**CO.5**
10	Multiple sequence alignments (Clustal) and Phylogenetic Analysis. (Phylip or Clustal)	**CO.5**
11	Gene Prediction.	**CO.5**

References

- Gerhardt P. Murray RG, Wood WA, and Kreig NR (ed.) (1994) Methods for General and Molecular Bacteriology - American Society for Microbiology, Washington D.C.
- Patrick R. Murray. (editor chief) (1999) Manual of clinical microbiology, 7 Th edition, ASM Press, Washington D.C.
- Prakash M., Arora, C.K. (1998) Pathological techniques - Anmol Publications Pvt. Ltd. N.D.
- Sambrook J, Fritsch EF, Maniatis T. (1989). Molecular coloning. Cold Spring Harbor Laboratory Press.
- Sambrook J and Russell DW (2001) Molecular cloning - A laboratory manual (3 Rd edition, Vol 1,2,3), Cold Spring Laboratory Press, New York.
- Ausubel FM (1994) Current protocols in molecular biology, Vol. 1 & 2. John Wicey & Sons Inc.

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	3	3	1			3	3	3	3		3	2
CO2	3	3	1			3	3	3	3		3	2
CO3	3	3	1			2	1	3	3		3	2
CO4	3	3	1			3		3	2	3	3	2
CO5	3	3	1			2	2	3	2	3	3	2
BS418	**3**	**3**	**1**			**3**	**2**	**3**	**3**	**2**	**3**	**2**

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. MB I[st] yr,
Semester: II[nd]

BS-419 Educational/Industrial Tour

L T P C
0 0 0 0

Course Objectives:
The main objective of this course is to provide the students an exposure to various research activities in the country and acquaint the student with state of the art technique/instruments used in various research institutions and industries of national repute. The student needs to submit a report after completion of the tour.

Course Outcome (CO)

CO.1 Develop understanding of state of the art techniques/instruments used in various reputed research institutions. and industries

CO.2 Take part in Group discussion and learn Team work.

CO.3 Enhance communication and social skills by communication with peers.

CO.4 Student shall be able to plan and improve the Technical Report writing skills

CO.5 Have created Interest to pursue lifelong learning.

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	3	1	1			2		3	2	2	3	3
CO2	3	2	2	1				1				3
CO3	3	2	2	1				1				3
CO4	3	2				2		2	2	2		3
CO5	3			1				3	2	2		3
BS419	**3**	**2**	**1**	**1**		**1**	**-**	**2**	**2**	**2**	**1**	**3**

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. MB II[nd] yr,
Semester: III[rd]

BS-541 Medical Microbiology

L T P C
3 1 0 4

Course Objectives:
To introduce basic principles and application relevance of clinical disease. It covers all biology of bacteria, viruses and other pathogens related with infectious diseases in humans.

Course Outcome (CO)

CO.1 Gain information about the concepts of medical microbiology and gain knowledge on medically important micro-organisms, classification and normal flora of human body.

CO.2 Gain knowledge of diseases and types of infections; mechanism of microbial pathogenesis; endo and exotoxins; sample collection and identification.

CO.3 Understand Systematic Microbiology; diagnosis, identification and prevention of pathogenic microorganisms.

CO.4 Gain knowledge on Water borne infections caused by bacteria.

CO.5 Gain knowledge on Nosocomial infections and various chemotherapeutic agents and their mode of action including alternatives of antibiotics and Alternative and Complimentary medicine.

Unit	Course Contents:	Mapped CO	hours
I	**Principles of Medical Microbiology** Classification of medically important micro-organisms. Normal flora of human body – Origin of normal flora, role of the resident flora, effect of antimicrobial agents on normal flora, factors influencing normal flora (Skin, conjunctiva, nose, nasopharynx, sinuses, mouth, upper respiratory tract, intestinal tract, urogenital tract).	**CO.1**	**8**
II	**Clinical conditions and diagnosis** Factors that influence pathogenicity; Type of infections, source of infections, different modes/means of infections; Diagnostic microbiology – Types of specimen, specimen collection, transportation of specimen, processing; Laboratory diagnosis-haematology, biochemistry, microbiology, serology, radiology and other special methods.	**CO.2**	**8**
III	**Systematic Microbiology** Detailed study of morphology, cultural characteristics, antigenic structure, pathogenesis, epidemiology, prevention and treatment of the following bacterial pathogens. Air borne infections caused by bacteria–Haemolytic streptococci, Pneumococci, Corynebacterium diphtheriae, Mycobacterium spp., Neisseria meningitidis, Haemophilus influenzae. Sexually transmitted diseases caused by bacteria, Treponema pallidum, Neisseria gonorrhoeae.	**CO.3**	**8**
IV	**Water borne infections caused by bacteria** *E. coli, Salmonella typhi, Shigella dysenteriae, Vibrio cholera*; Wound infections caused by bacteria – Staphylococcus aureus, Clostridium tetani, Pseudomonas; Important fungal diseases and their prevention.	**CO.4**	**8**

V	**Nosocomial infections & Therapies** Factors that influence hospital infection, hospital pathogens, route of transmission, investigation, prevention and control. Preventive Measures: Antibiotics and chemotherapeutic agents-drug resistance and antibiotic policy; Epidemiology and control of community infection. Alternative and Complimentary medicine-Chinese, European and Indian (Siddha, Ayurveda, Unani etc).	**CO.5**	**8**

References

- Chaechter M. Medoff G. and Eisenstein BC. (1993) Mechanism of Microbial Diseases 2nd edition.
- Williams and Wilkins, Baltimore.
- David Greenwood, Richard CD, Slack, John Forrest Peutherer. (1992) Medical Microbiology. 14th edition. ELBS with Churchill Livingstone

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	**3**	**1**			**1**	**3**	**1**	**2**	3			
CO2	**3**	**1**			**1**	**3**	**1**	**2**	3		2	
CO3	**3**	**1**				**3**	**1**	**2**	3			
CO4	**3**	**1**				**3**	**1**	**2**	3			
CO5	**3**	**1**		**1**	**1**	**3**	**1**	**3**	3		3	
BS541	**3**	**1**		**1**	**1**	**3**	**1**	**1**	**3**		**1**	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. MB II[nd] yr, Semester: III[rd]

BS-542 Fundamentals of infection & Immunity

L T P C
3 1 0 4

Course Objectives:

The objective of the course is to apprise the students about components associated with immune system and molecular mechanism of their working. The course also deals with implications of deregulation of basic regulatory networks that lead to immune system related disorders. The students will be able to describe the roles of the immune system in both maintaining health and contributing to disease.

Course Outcome (CO)

CO.1 The student will learn the fundamental principles of immune response including molecular, biochemical and cellular basis of immune homeostasis

CO.2 The course will aid in understanding various aspects of immunological response and how its triggered and regulated.

CO.3 The student will learn and understand the rationale behind various assays used in immunodiagnosis of diseases and will be able to transfer knowledge of immunology in clinical scenario.

CO.4 The course will aid in understanding the principles of Graft rejection, Auto immunity and Antibody based therapy.

CO.5 The student will develop the capacity for problem-solving about immune responsiveness, knowledge of the pathogenesis of diseases and designing of immunology-based interventions for effective treatment.

Unit	Course Contents:	Mapped CO	hours
I	**Fundamentals of Immunology** Cells and organs of immunity: Memory, specificity, diversity, self vs. non-self discrimination, Structure of primary and secondary lymphoid organs, Cell mediated vs. humoral immunity, T and B-lymphocytes; Nature of antigen and antibody: Antigen vs. Immunogen, Structure of antibody: constant and variable regions, Fab and Fc; isotype, allotype and idiotype; Abzymes..	**CO.1**	**8**
II	**Antigen-antibody interactions and its measurement** Direct binding assays, Agglutination and precipitation, radioimmunoassay and ELISA, fluorescence analysis, Hybridoma technology, applications of monoclonal antibodies in biomedical research, clinical diagnosis and treatment.	**CO.2**	**8**
III	**Generation of diversity in the immune response** Clonal selection theory-concept of antigen specific receptors, genes encoding antigen specific receptors on T and B-lymphocytes, genetic rearrangement, class switch, Comparison of receptors and B and T lymphocytes.	**CO.3**	**8**
IV	**Differentiation of B and T lymphocyte** Activation of T cells and B cells by antigen: Antigen processing, Antigen presentation to T cells, Products and factors released by T cell activationinterleukins, interferons, B cell activating factors, T cell and B cell	**CO.4**	**8**

	interactions leading to antibody synthesis. Central role of major histocompatibility complex (MHC), genes and products in immune response: T cell recognition of antigen and MHC products, Structure of MHC gene complex and its products polymorphism of MHC gene products, Associated MHC functions-allograft, graft vs. host and mixed leucocyte responses.		
V	**Tolerance vs. activation of immune response** Complement- components of classical and alternative pathways. Hypersensitivity: Types I, II, III and IV responses. Autoimmunity. Host Immune Response against intracellular and extracellular microbes; Principles and strategy for developing vaccines	**CO.5**	**8**

References

- Ivan M. Roit. (1994) Essential Immunology - Blackwell Scientific Publications, Oxford.
- Janeway travers. (1997). Immuno biology - The immuno system in health and disease 3rd edition Current
- Biology Ltd., London, New York
- Immunology: Kuby
- Instant Notes : Lydyard, Whelan, Fanger
- Immunology: Pathak

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	**3**	**1**				**3**		**1**		3		
CO2	**3**	**1**				**3**		**1**		3	3	
CO3	**3**	**1**				**3**		**1**		3		
CO4	**3**	**1**				**3**		**1**		3		
CO5	**3**	**1**				**3**		**1**		3	3	
BS542	**3**	**1**				**3**		**1**		**3**	**2**	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. MB II[nd] yr,
Semester: III[rd]

BS-543 Recombinant DNA Technology

L T P C
3 1 0 4

Course Objectives:
The objectives of this course are to develop the understanding of Genetic Manipulations and introduce the concepts of different Enzymes, concept of Transformation, Gene Cloning and its expression, transgenic plants, animal, GMOs

Course Outcome (CO)

CO.1 Learn about different enzymes used in genetic engineering for DNA manipulations.
CO.2 Have knowledge of different plasmid vectors and their characteristics
CO.3 Have knowledge of different cloning vectors and their characteristics
CO.4 Have knowledge of Transformation methods and their use in Genetic Engineering. Determine the selection parameters of r-DNA, creation of different gene libraries.
CO.5 Have knowledge of sequencing techniques and using genetic engineering for mutagenesis, gene silencing, and amplification of DNA, DNA Sequencing

Unit	Course Contents:	Mapped CO	hours
I	**Restriction endonucleases** Class I, II & III restriction enzymes, Nomenclature, Isoschizomers, Heterohypekomers, Unit of restriction enzymes, Restriction digestion: partial and complete, Star activity; Homopolymer tailing, Synthetic Linkers, Adaptors; Roles of DNA ligase, T4 DNA polymerase, Alkaline phosphatase, Reverse transcriptase in cloning .	**CO.1**	**8**
II	**Plasmids** Plasmid size range, Plasmid classification on basis of phenotypic traits: Cryptic, Fertility, Resistance, Bacteriocinogenic, Degradative, Virulence; Conjugative / non conjugative plasmids; Relaxed and stringent control of copy number; Plasmid incompatibility; Plasmid host range, Mobilizable plasmids and Triparental mating; Plasmid as cloning vector (recombinant plasmids): Properties of ideal plasmid cloning vectors, Plasmid vectors for E. coli and Agrobacterium; Transcriptional and translational fusion vectors; Selectable markers; Reporter genes.	**CO.2**	**8**
III	**Cloning vectors** Phage lambda vector, In vitro packaging, Insertional and replacement vectors; Cosmid vectors; M13 phage; Phagemids; Yeast as cloning vector: Basic principles of development of yeast vectors, 2□ plasmid, YEP, YRP YCP, YIP; Artificial chromosomes: YACs, BACs and PACs.	**CO.3**	**8**
IV	**Basic Techniques - I** Gene bank / Genomic library and cDNA library construction; Overview of techniques for recombinant selection and screening: Functional and nutritional	**CO.4**	**8**

	complementation, Colony/ plaque hybridization, Plus-Minus screening, Immunological screening, HART, HAT.		
V	**Basic Techniques - II** Rapid DNA sequencing techniques: Sanger method, Maxam and Gilbert procedure, automated DNA sequencing, pyrosequencing; Genomics: High throughput Sequencing: Microarray; Principle & applications of PCR: RT PCR, Inverse PCR, RACE, Degenerate PCR, , Real time PCR, Scorpion PCR, Applications of PCR in gene cloning, TA cloning, pathogen diagnostics, environmental monitoring; Site directed mutagenesis; Antisense RNA technology and its applications.	**CO.5**	**8**

References

- Freifelder, DM “Molecular Biology”.
- Brown, TA “Genomes”.
- Rastogi &Pathak Genetic Engineering
- Brown, T.A. “Gene cloning: An introduction”
- Old & Primrose “Principles of Gene Manipulation”
- Primrose, SB “Molecular Biotechnology”

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	**3**	**1**				**3**		**1**		3		
CO2	**3**	**1**				**3**		**1**		3		
CO3	**3**	**1**				**3**		**1**		3		
CO4	**3**	**1**				**3**		**1**		3		
CO5	**3**	**1**		**1**	**2**	**3**	**1**	**1**		3		
BS543	**3**	**1**		**1**	**2**	**3**	**1**	**1**		**3**		

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. MB II[nd] yr,
Semester: III[rd]

BS-544 Virology & Biosafety

L T P C
3 1 0 4

Course Objectives:
This course is designed to introduce the structure of viruses, provide knowledge on fundamentals of virology; Develop understanding of infection processes at the molecular level; introduce a concept of biosafety against infection or genetic modification.

Course Outcome (CO)

CO.1 Know how viruses are classified, diverse viral architecture and genome structure and know the methods used in studying them.

CO.2 Understand the architecture of plant viruses and their genomes, gene expression, mode of replication and transmission.

CO.3 Understand the architecture of animal viruses and their genomes, gene expression, mode of replication, the intricate interaction between viruses and host immune cells and pathogenesis of virus-induced diseases and oncogenesis and know about new and emerging animal viruses as Ebola Virus, Zika Virus, SARS and SARS-CoV2

CO.4 Understand the replication and growth of bacteriophages and lysogenic switch, study other virus related structures and evolution of viruses.

CO.5 Assess the proper use of biological containment, and be introduced to safely conduct research, and bioethics in research, identify the role of the biosafety professional in biomedical research laboratories.

Unit	Course Contents:	Mapped CO	hours
I	**General Virology** Brief outline of virology; Discovery and origin of virus; Early development of virology – nomenclature - classification and taxonomy of viruses - based on host, nucleic acids and structure; Concept of ICTV nomenclature and classification of viruses (as per 9th Edition, 2008); Detection and isolation of viruses.	**CO.1**	**8**
II	**Plant Viruses** Effects of viruses on plants: Morphological, histological and physiological changes; Transmission of plant viruses: a. through vectors- insects, nematodes and fungi b. without vectors- contact, seed and pollens; Life cycles of plant viruses– TMV, Cauliflower Mosaic Virus.	**CO.2**	**8**
III	**Animal viruses** Retro virus-HIV; Hepatitis viruses–HBV, Influenza virus; Polio virus: General characters, life cycle, pathogenicity and diseases. Immunologic responses of the viruses in Animals; Oncogenic viruses: Virus induced cell transformation and oncogenesis. New and Emerging Animal Viruses: Ebola Virus, Zika Virus, SARS and SARS-CoV2	**CO.3**	**8**
IV	**Bacteriophages, Evolution of viruses and other viral types** Replication of single and double stranded nucleic acids of bacterial viruses, Onestep growth curves of bacteriophages, structure and genetics of phage lambda.	**CO.4**	**8**

	Evolution of viruses and brief account of other viral types: Evolution of viruses; Virus related structures – viroids and prions; Satellite RNAs, Virusoids.		
V	**Biosafety and Bioethics** Historical Backround; Introduction to Biological Safety Cabinets; Primary Containment for Biohazards; Biosafety Levels; Biosafety guidelines - Government of India; Definition of GMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC etc. for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication. Bioethics: Introduction, necessity and limitation; Ethical conflicts in Biotechnology; Different paradigms of bioethics.	**CO.5**	**8**

References

- Edward K. Wagner, Martinez J. Hewlett, (2004), *Basic Virology*, Blackwell Publishing
- 2. Flint S. J., V. R. Racaniello, L. W. Enquist, V. R. Rancaniello, A. M. Skalka, (2003), *Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses*, American Society Microbiology, Chapters 3-13
- Conrat HF, Kimball PC and Levy JA. (1988). Virology. II edi. Prentice Hall, Englewood Cliff, New Jersey.
- Dimmock NJ, Primrose SB. (1994) Introduction to Modern Virology IV edi. Blackwell
- Timbury MC. (1994) Medical Virology X edition. Churchill Livingston.
- Topley & Wilson's. (1990) Principles of Bacteriology, Virology and Immunity VIII edition Vol. IV Virology, Edward Arnold, London.
- Alan Cann (2001) Molecular Virology
- Madigam M.T., Martinko J.M and Parker J. Brock Biology of Microorganisms 9th ed. Prentice Hall Int. (U.K.) Ltd, London.
- International Congress on Taxonomy of Viruses: http://www.ncbi.nlm.nih.gov/ICTV

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	3	1				3	1	1	3			
CO2	3	1				3	1	2	3			
CO3	3	1				3	1	2	3			
CO4	3	1				3	1	1	3			
CO5	3	1	3	3	3	3	2	3	3			3
BS544	**3**	**1**	**1**	**1**	**1**	**3**	**2**	**1**	**3**			**1**

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. MB II[nd] yr,
Semester: III[rd]

BS-545 Food & Dairy Microbiology

L T P C
3 1 0 4

Course Objectives:
To provide knowledge of microorganisms (pro-technological, probiotic, pathogens and spoilage) associated with foods and their origin and role; Knowledge of the factors that determine the presence, growth and survival of microorganisms in food and gain knowledge about fermentation techniques used in dairy industry, role of microorganisms in fermentation and to gain skills to control fermentation process.

Course Outcome (CO)

CO.1 Learn about fundamentals of food microbiology.
CO.2 Gain insight on spoilage of foods by microbes, microbial food poisoning.
CO.3 Understand the process of fermentation of milk and other food items.
CO.4 Assessment of food quality in reference to microbial contamination.
CO.5 Quality control, packaging, processing parameters of various foods, BIS Laboratory services, certification and licensing of food products .

Unit	Course Contents:	Mapped CO	hours
I	**Foods and their composition** Types of microorganisms with reference to food and dairy industry- Psychrophiles, osmophiles, halophiles, thermophiles, pH-tolerance and spore formers. Food spoilage - Causes of spoilage, classification of foods by ease of spoilage, Factors affecting the growth of microorganisms in foods. Chemical changes caused by microorganisms.	**CO.1**	**8**
II	**Microbial flora & their spoilage** Microbial flora and spoilage of meat, fish, fish products, eggs, milk and milk products, fruits, vegetables, bakery products and canned foods. Canned foods: processes, advantages and defects. Methods of food preservation - General principles, preservation by use of chemicals, high temperature, low temperature and irradiation and drying processes, aseptic packaging materials.	**CO.2**	**8**
III	**Fermentation of foods** Types, production and defects. Fermentation of pickles, Butter, cheese, creams, yogurt and ice creams. Role of microbes and microbial enzymes in the fermentation of tea, coffee and Cocoa and production of silage.	**CO.3**	**8**
IV	**Milk and milk products** Composition, factors affecting composition of milk, Spoilage of milk and milk products. Milk borne disease, antimicrobial systems in milk, sources of contamination of milk. Chemical and microbiological examination of milk, grading of milk. Starter lactic cultures, biochemical basis of culturing dairy product, management and preparation of starter cultures, starter defects, probiotics.	**CO.4**	**8**

V	**Food sanitation, Indicator organism** Detection of microorganisms in foods. Food poisoning and food infections. Food quality and assurance: Quality control parameters of various foods with special reference to microbiological quality. Importance of microbiological quality during food processing and packaging. Food borne diseases, their causative agents and control measurers.	**CO.5**	**8**

References

- Milk and Milk Products –Fourth ed. Clarence Henry Eckles TMH Publ.
- Frazier WC and Westhoff DC. (1988) Food microbiology, TATA McGraw Hill Pub. Food
- Microbiology – J.De and De
- Food processing :Biotechnological Applications –(2000) S.S.Marwaha &Arora, Asitech Adams
- MR and Moss MO. (1995). Food Microbiology, The Royal Society of Chemistry, Cambridge.

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	**3**	**1**				**3**	**2**	**3**	3			
CO2	**3**	**1**				**3**	**2**	**3**	3			
CO3	**3**	**1**				**3**	**2**	**3**	3	1	3	
CO4	**3**	**1**		**1**		**3**	**2**	**3**	3		3	
CO5	**3**	**1**	**1**	**2**	**3**	**3**		**3**				3
BS505	**3**	**1**		**1**	**1**	**3**	**2**	**3**	**3**	**1**	**2**	**1**

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. BT IInd yr,
Semester: IIIrd

BS-546 RDT and Immunology Lab

L T P C
0 0 12 6

Course Objectives:
The lab is designed to train the students to use the immunology and molecular biology techniques for advanced genetic engineering practicals.

Course Outcome (CO)

CO.1 Capable of performing chromatography techniques: Paper/Column/TLC

CO.2 Able to isolate and visualize plasmid DNA, prepare competent cells and carry out transformation and restriction digestion.

CO.3 Capable of setting up PCR reactions, blotting (Southern and Northern) and separating proteins by SDS-PAGE

CO.4 Capable of identifying antigen & antibody interactions by double Immunodiffusion: Ouchterlony's Method, performing Immunoelectrophoresis and Enzyme Linked Immunosorbent Assay (ELISA)

CO.5 Learn how to determine blood Group, Total WBC count and Total RBC count

S.No.	Experiments:	Mapped CO
1	Chromatography techniques: Paper/Column/TLC	**CO.1**
2	Isolation of plasmid DNA from bacteria	**CO.2**
3	Size characterization of DNA by agarose gel electrophoresis.	**CO.2**
4	Preparation of competent E. coli cells and transformation of plasmid DNA to the E. coli cells	**CO.3**
5	Restriction digestion & ligation	**CO.3**
6	Southern blotting and northern blotting	**CO.3**
7	PCR amplification – demonstration.	**CO.3**
8	Separation of proteins by SDS – PAGE and native gel.	**CO.3**
9	To identify sensitivity of antigen & antibody by double Immunodiffusion: Ouchterlony's Method, Immunoelectrophoresis	**CO.4**
10	Determination of blood Group, Total WBC count and Total RBC count	**CO.5**
11	Enzyme Linked Immunosorbent Assay (ELISA)	**CO.4**

References

- Keith Wilson John Walker John M. Walker "Principles and Techniques of Practical Biochemistry" Chirikjian "Biotechnology Theory & Techniques"
- Joseph Sambrook David W. Russell Joe Sambrook "Molecular Cloning: A Laboratory Manual"

William M., Ph.D. O'Leary Robert Dony Wu "Practical Handbook of Microbiology"
- Brown, TA "Gene cloning: An introduction"
- Plummer David T., (1988), An introduction to practical biochemistry, 3rd Ed., Tata McGraw-Hill Publishing Co. Ltd. New Delhi, 109-121
- Talwar G. P. (1983) *Handbook of Immunology*, Vikas Publishing Pvt. Ltd. New Delhi

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	**3**	**3**	**1**			**3**		**3**		2	3	2
CO2	**3**	**3**	**1**			**3**		**3**		2	3	2
CO3	**3**	**3**	**1**			**3**		**3**		2	3	2
CO4	**3**	**3**	**1**			**3**		**3**		2	3	2
CO5	**3**	**3**	**1**			**3**		**3**		2	3	2
BS546	**3**	**3**	**1**			**3**		**3**		**2**	**3**	**2**

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. MB II[nd] yr,
Semester: Iv[th]

BS-551 Environmental Microbiology

L T P C
3 1 0 4

Course Objectives:
To know and understand the role of microbes in biogeochemical processes within different ecosystems. The students will learn the basic microbiological principles, the methods in microbial ecology and their theoretical and practical use.

Course Outcome (CO)

CO.1 Understanding about water and air microbiology, biological indicators of pollution, bacteriological examination of water, BOD and anthropogenic pollution.

CO.2 Environmental pollution: types, xenobiotics, genotoxicity, Mutation detection by ames test, bioremediation and toxicogenomics.

CO.3 Recycling of organic wastes: recycling crop, human and animal wastes. Composting and vermicomposting; biogas production and waste treatment.

CO.4 Knowledge about microbes of toxic environments, microbial degradation of xenobiotics, pesticides, heavy metals, acid mine drainage.

CO.5 Understanding biodeterioration concept: biodeterioration of wood, stonework, pharmaceutical products, rubber, plastic paints, lubricants, cosmetics and control of biodeterioration.

Unit	Course Contents:	Mapped CO	hours
I	**Microbiology of air and aquatic environments** Microbiology of air and aquatic environments - Bacteriological indicators of pollution, Bacteriological examination of water, nuisance bacteria in water systems. Chemical and microbiological characteristics, Biological Oxygen Demand (BOD), Microorganisms and pollution problems and interaction with human bodies.	**CO.1**	**8**
II	**Environmental pollution** Environmental pollution: Definition, source and types of pollution (air, water and soil). Xenobiotic toxicity/ genotoxicity, Mode of action of pesticides, fungicides and insecticides; Mutation detection by Ames, microsomal assay. Bioaccumulation and bioremediation, Biosensors, DNA probes and their environmental applications, Toxicogenomics.	**CO.2**	**8**
III	**Recycling of organic waste interactions** Recycling of organic waste: Major sources of recyclable materials including agricultural waste. Key technology in recycling of crop residues, human and animal wastes. Composting and vermicomposting; Production and application. Role of microbes in composting and biogas production. Municipal solid waste treatment and management.	**CO.3**	**8**

IV	**Microbes of toxic environments** Microbial biotransformation/ degradation of organic pollutants in soil. Microbial degradation and persistence of xenobiotics, pesticides, herbicides, heavy metals and radio isotopic materials. Pesticides toxicity to microbes and plants. Acid mine drainage, coal desulphurization.	**CO.4**	**8**
V	**Biodeterioration** Biodeterioration-concept, biodeterioration of wood, stonework, pharmaceutical products, rubber, plastic, paints, lubricants, cosmetics, control of biodeterioration	**CO.5**	**8**

References

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- Ec Eldowney S, Hardman DJ, Waite DJ, Waite S. (1993). Pollution: Ecology and Biotreatment Longman Scientific Technical.
- Grant WD, Long PL. (1981) Environmental Microbiology. Blackie Glasgow and London.
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Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	**3**	**1**				**3**	**1**	**1**	3	1	3	
CO2	**3**	**1**				**1**		**1**	3	1	3	
CO3	**3**	**1**				**1**		**1**	3	1	3	
CO4	**3**	**1**				**3**	**1**	**1**	3	1	3	
CO5	**3**	**1**				**3**	**1**	**1**	3	1	3	
BS551	**3**	**1**				**3**	**1**	**1**	**3**	**1**	**3**	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. MB II[nd] yr,
Semester: Iv[th]

BS-552 Commercial & Applied Microbiology

L T P C
3 1 0 4

Course Objectives:
The aim of this course is to impart the knowledge of basic principles of Microbiology and their applications to humankind.

Course Outcome (CO)

CO.1 Learn about the biotechnological application of microalgae.
CO.2 Learn about the production and significance of biofertilizers
CO.3 Gain knowledge of Microbial genomics and proteomics.
CO.4 Acquire knowledge on production of single cell protein and its merits and demerits.
CO.5 Learn application of microbes in antibiotics, acids, alcohol, vitamins production in industry

Unit	Course Contents:	Mapped CO	hours
I	**Microbial Biotechnology** Microbial Biotechnology - Definition, Concepts and history, biotechnological potentials of micro algae – food – feed – colourant – fuel and pharmaceutically valuable compounds.	**CO.1**	**8**
II	**Production of microbial biofertilizers** Production of microbial biofertilizers–Cyanobacteria, *Rhizobium, Azotobacter*, *Azospirillum*, *Phosphobacteria* and vesicular arbuscular mycorrhiza.	**CO.2**	**8**
III	**Microbial Genomics & Proteomics** Microbial Genomics – definition, whole genome analysis – automated sequences – physical methods and sequencing. Genome expression and its analysis – methodologies – serial analysis – Oligo NT array technology – cDNA microarrays and microchips. Proteomics–definition–multidimensional protein identification technology–identification using database.	**CO.3**	**8**
IV	**Production of single cell protein** Production of single cell protein - Microorganisms and substrates used, techniques of production, nutritional value of single cell protein, economics of production, merits and demerits of single cell protein.	**CO.4**	**8**
V	**Industrial microbes and their products** Industrial microbes and their products A brief idea about the products obtained from microbes – biology of industrial microorganisms such as Streptomyces, yeasts, *Spirulina* and *Penicillium* – commercial production of penicillin, ethanol, vinegar, vitamin B12, Protease, citric acid and glutamic acid from microbial sources– production of commercially useful non-microbial products produced through recombinant microbes.	**CO.5**	**8**

References

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- Stanbury PF, Whitaker A, Hall SJ. (1995) Principles of Fermentation Technology, Pergamon Press.

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	**3**	**1**				**2**	**1**	**1**	1		3	
CO2	**3**	**1**				**3**	**1**	**1**	1		3	
CO3	**3**	**1**				**3**		**1**	1		3	
CO4	**3**	**1**				**3**	**1**	**1**	1		3	
CO5	**3**	**1**				**3**	**1**	**1**	1		3	
BS512	**3**	**1**				**1**	**1**	**1**	**1**		**3**	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. MB II[nd] yr,
Semester: Iv[th]

BS-553 Pharmaceutical Biotechnology

L T P C
3 1 0 4

Course Objectives:
This course enables the students to learn the various aspects of pharmaceutical sciences. In this course, students get exposed to the insights into various therapeutic strategies against infectious and non-infectious diseases i.e. via monoclonal antibodies (mABs), peptide based therapeutics, liposome/emulsion-based drug delivery systems, PEG-conjugates-based drug delivery and various factors affecting the drug delivery, its release, and absorption.

Course Outcome (CO)

CO.1 Understand the principle of monoclonal antibodies generation, their mode of action, and their application in targeting various diseases.

CO.2 Formulate therapeutic proteins and peptides, their encapsulation with other macromolecules and implications in drug delivery.

CO.3 Prepare lipid-based drug delivery systems as well as PEG-conjugates for fast drug delivery and release inside the body.

CO.4 Develop the strategies of pulmonary drug delivery.

CO.5 Apply the knowledge of polymers for production of biopharmaceuticals with controlled drug delivery.

Unit	Course Contents:	Mapped CO	hours
I	**Monoclonal antibodies** Monoclonal antibodies: applications, generation, recombinant antibodies, production methods, Pharmaceutical, regulatory and commercial aspects.	**CO.1**	**8**
II	**Formulation of proteins and peptides** Formulation of proteins and peptides: making small protein particles, precipitation of proteins, quality control issues, multi-phase drug delivery system; Preparation of collagen, gelatin particles, albumin microparticles.	**CO.2**	**8**
III	**Proteins and phospholipids** Proteins and phospholipids: structural properties of phospholipids, injectable lipid emulsions, liposomes, cochleal phospholipids structures; Polymeric systems for oral protein and peptide delivery.	**CO.3**	**8**
IV	**Pulmonary drug delivery systems for biomacromolecules** Pulmonary drug delivery systems for biomacromolecules; Lipid based pulmonary delivery; Solid colloidal particles; Polycyanoacrylates; Poly (ether-anhydrides);	**CO.4**	**8**

	Diketopiperazine derivatives; Poly ethylene glycol conjugates; Factors affecting pulmonary dosing		
V	**Polymers used for controlled drug delivery** Polymers used for controlled drug delivery: Hydrophobic polymers poly(esters), poly(cyanoacrylate), poly (ortho esters), poly (phosphazenes), Hydrophobic polymers poly (alkyl methacrylates), poly (methacrylates), poly (acrylates)], alginates, chitosan, polyethylene glycol. Gene therapy: the current viral and non-viral vectors.	**CO.5**	**8**

References

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- Kayser O, Muller R „Pharmaceutical Biotechnology".
- Banga AK „Therapeutic peptides and proteins
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Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	3	1		1		3		2		2	3	
CO2	3	1		1		3		2			3	
CO3	3	1		1		3		2			3	
CO4	3	1		1		3		2		1	3	
CO5	3	1		1		3		2		1	3	
BS553	**3**	**1**		**1**		**3**	**-**	**2**		**1**	**3**	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. MB II[nd] yr,
Semester: Iv[th]

BS-514 Seminar

L T P C
3 1 0 2

Course Objectives:
The students will be able to summarise and present the existing data related to a specific topic in the form of a report. Every student will present a seminar on a topic related to theoretical or experimental, advanced topic.

Course Outcome (CO)

CO.1 The students will understand and interpret latest advancements through different technical papers, reports, Journals, Data sheets, books etc

CO.2 The students will inculcate the skills for literature survey and will learn to manage resources effectively.

CO.3 The students will be able to summarize the recent research and technologies in the form of review and will be able to deliver power point presentations on an assigned topic.

CO.4 Communicate his/her ideas with his peers as audience, which will enhance both oral and written communication skills.

CO.5 Create interest to pursue lifelong learning.

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	3	2			1	2	1	2	3	-	1	3
CO2	3					2		2				3
CO3	3	2	1			2		2			1	3
CO4	3	3	3					2	3			3
CO5	3							3				3
BS514	**3**	**2**	**1**		**1**	**2**	**1**	**3**	**3**		**1**	**3**

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INTEGRAL UNIVERSITY LUCKNOW

M.Sc. MB II[nd] yr,
Semester: Iv[th]

BS-515 Project Work

L T P C
0 0 12 8

Course Objectives:
The main objective of this course is to develop independence in experimental design and interpretation and to develop research skills. To promote education and research in biotechnology and provide academic and professional excellence for immediate productivity in industrial, governmental, or clinical settings for an ultimate benefit of society and environment.

Course Outcome (CO)

CO.1 Perform literature review, identify state of the art in that field.

CO.2 To be able define the problem and develop synopsis of a defined research problem

CO.3 Establish a methodology using advanced tools / techniques for solving the problem including project management and finances.

CO.4 To prepare the research report and its oral demonstrations.

CO.5 Have gained practical experience in project management in biotechnological industry, be able to use various techniques in contemporary research for project, perform numerical analysis and Interpret the results

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
CO1	3					3	1	3	2	1	3	3
CO2	3					3	1	3	2	1		3
CO3	3					3		3			3	3
CO4	3	2				3		3	2	1		3
CO5	3		2	3		3		3	2	1	3	3
BS515	**3**	**1**	**1**	**1**	**-**	**3**	**1**	**3**	**2**	**1**	**2**	**3**

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

M.Sc. Microbiology

Program Articulation Matrix: (Mapping of Courses with POs and PSOs)

PO-PSO / Course	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	POS2	PSO3	PSO4
BS401	3	1				-	-	1	3	3	1	
BS402	3	1		3	1	3	1	1	2	1	2	2
BS403	3	1				-	-	1	3			
BS404	3	1				3	-	1			3	
MT403	3	1				3	-	1				3
BS405	3	3	1	1		3		3	2		3	2*
BS411	3	1				-	-	1	3			
BS412	3	1				2		1	3		1	
BS413	3	1				-	-	1	3			
BS414	3	1			1	2	3	1	3	1	1	
BS415	3	1			1	2	1	1	3		1	1
BS416	3	1				2	3	1	3	1	2	
BS417	3	1		1		3	-	2	2		3	
BS418	3	3	3	1	1	3	1	3	2		3	2*
BS419 (audit course)	3	2	1	1		1	-	2	1		1	3
BS501	3	1				3	-	1	1		3	
BS502	3	1				2	1	2	2	2	3	
BS503	3	1				-	-	1	3		1	
BS504	3	1			2	3	-	1	1	1	3	
BS505	3	1		1	1	2	1	1	3		1	
BS506	3	3	1		1	3	1	3	1		3	2*
BS511	3	1		3	1	3	-	1	1		3	
BS512	3	1				1	-	1	3			
BS513	3	1	1	2	-	2	1	1	3		2	
BS514	3	2	1			2	-	3	2		1	3
BS515	3	1	1	1	-	3	-	3	2		2	2
M.Sc. Microbiology	**3**	**2**	**2**	**2**	**2**	**3**	**2**	**2**	**3**	**2**	**2**	**3**

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation