Sri Padmavati Mahila Visvavidyalayam
TIRUPATHI-517502
Department of Applied Microbiology

M.Sc., Industrial Microbiology
[Choice Based Credit System (CBCS)]

Program outcomes (PO), Program specific outcomes (PSO) and Course outcomes and SYLLABUS
(With effect from the academic year 2020-2021 onwards)

M.Sc., Industrial Microbiology

Learning outcomes (LO), Program specific outcomes (PSO) and Course outcomes and SYLLABUS
(With effect from the academic year 2020-2021 onwards)

Introduction

Industrial Microbiology is a Post graduate program in Microbiology designed to educate the students on various aspects of microbiota and their relationship with environment. The curriculum of the program comprises courses on Basics of microbiology, Immunology, Biomolecules and metabolism, Analytical techniques and biostatistics, Medical microbiology, Molecular biology, Virology, Immunotechnolgy & molecular signalling, Enzyme technology , Bioinformatics, Recombinant DNA technology, Fermentation technology, Bioremediation, Animal pharmaceutical biotechnology, molecular and Immuno diagnostics, Research methodology, Public health communication , Omic tools for microbial bioprospecting, Agri biotechnology, Techno entreneurship & bioethics.

The syllabus of each course is constructed to Provide students with a theoretical and practical Conceptual knowledge on emergence of recombinant DNA technology from knowledge gained in biochemistry, genetics, cell biology and molecular biology and to understand the basic principles and techniques in genetic manipulation and genetic engineering, describe gene transfer technologies for animals and animal cell lines. All the courses provide the overview and encourage the graduate with outcome based education pattern which provide space for Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation (KL, AL1, AL2, EL & SC).

General Graduate Attributes:

- Communication skills: The graduates attain the ability to communicate the information on microbiota and their applications through oral presentations and reports.
- Research related skills: the students gain knowledge on the significance of important enzymes and cloning and able to analyse the scientific research in the advanced areas of microbiology.
- Team work: The students acquires the ability to work effectively as a member and leader within a team. The graduates are capable to utilize the strategic methods to work collaboratively in a team.

- Knowledge: The graduates will gains integrated knowledge on various branches of microbiology, like Immunology, Biomolecules and metabolism, Analytical techniques and biostatistics, Medical microbiology, Molecular biology, Virology,

Immunotechnolgy & molecular signalling, Enzyme technology, Bioinformatics, Recombinant DNA technology, Fermentation technology, Bioremediation, Animal pharmaceutical biotechnology, molecular and Immuno diagnostics, Research methodology, Public health communication, Omic tools for microbial bioprospecting, Agri biotechnology, Techno entreneurship & bioethics.

- Global Perspective: The students may gain the knowledge on the advanced and cutting edge issues of genomics, proteomics and trends in recombinant DNA technology as well as viruses.
- Critical thinking: Through the curriculum the students inculcate the skill in the practical application of scientific knowledge, including the ability to assimilateand analyze the microbiological information.
- Problem solving: The graduate will attain the ability to address the issues in microbiological and biochemical research
- Analytical reasoning: The students are trained in enhanced learning and analytical skills to understand the applications of microbiology
- Scientific reasoning: The graduates attain the knowledge to analyse and demonstrate scientific and experimental data.
- Digital literacy: The graduates sustain the skills to analyse bioinformatics and genomic tools through computational methods and microbial data bases.
  Entrepreneural competence: The students acquire an awareness an innovations and intellectual property rights , ethical issues and plagiarism tools.

Programme Specific Qualification Attributes

Programme specific qualification attributes achieved through courses in the programme in terms of

- Knowledge and understanding level (KL)
- Application level (AL1)
- Analytical level (AL2)
- Evaluation capability level (EL)
- Scientific or synthesis level (SL)

Program objectives

M. Sc. Industrial Microbiology course is designed to equip students with latest professional knowledge and technical skills in all specialization of Microbiology at industry level. It has well equipped laboratories with necessary infrastructure and trained teachers and technical faculty. The course emphasizes on the exploitation of the microorganisms for human welfare and the maintenance of environmental quality. The courses orient the students for

- Pursuing higher learning in research laboratories / Institutions in India & Abroad.
- Teaching in colleges / Universities.

- Self employment opportunities to set up Clinical and Analytical Laboratories.
- Placement in Pharmaceutical, Food Beverage and Biotechnology Industries.

PROGRAMME SPECIFIC OUTCOMES (PSOs):

PSO1: The Graduates will able to work independently on lab protocols involving isolation microbes from environment samples, immunological tools, biochemical techniques, identification of unknown pathogens, molecular techniques and genomics and proteomic tools.

PSO2: Plan and design experiments to establish scientific process and to synthesize several products through fermentation process / exploit the microbiota for the benefit of community.

PSO3: Microbiologist usually works in hospitals/ clinical laboratories, food industry, environment, research laboratories, beverage industry, pharmaceutical industry and will able to understand industrial processes, cleanrooms, and how to effectively evaluate microbial risks to products from people and processes.

Learning outcomes

LO1 Demonstrate the knowledge of basic concepts of microbiology, principles and applications of the microbial techniques for isolation, identification &growth parameters of bacteria and fungi.

LO2 Demonstrate the knowledge about the role of immune cells, organs and their functional mechanisms of each & diagnostic tests for antigen-antibody interactions.

LO3 Demonstrate the theoretical and practical knowledge of structure and metabolic functions of biomolecules. It also be useful to understand the technology of enzymes.

LO4 Ability to use with appropriate techniques and handle the equipment with standard operating procedures, safety aspects, limitations for separation and purification of biomolecules used in pharma&food industry ,designing microbiological experiment for statistical analysis, and interpretation of results

LO5 To acquaint the practical skills in the process of purification and quantification of nucleic acids and transfer of genes in bacteria and develop practical skills in tools and techniques used in r-DNAtechnology.

LO6 Demonstrate the theoretical and practical knowledge of virus classification, multiplication, pathogenic role, newly emerging virus and their control

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LO7 To acquaint with practical skills in various microbial fermentation processes , processes for commercially valuable products &attain knowledge about IPR and patents and learn appropriate methodologies, analyze and interpret data and provide solutions.

LO8 Demonstrate the theoretical and practical knowledge of bioremediation, xenobiotics, and effluent treatment methods and global environmental problems & online courses in relevant disciplines, build up Professionals in Pharmaceutical Analysis, immunodiagnostics.

LO9 To develop practical skills in understanding and manipulating the genetic makeup of agricultural products to increase its productivity & efficiency, development of professionals in Agricultural Biotechnology.

LO10 To promote development of techno entrepreneurship and build up Professionals in R&D work and develop practical skills effectively to accomplish research tasks independently/ diverse teams and in multidisciplinary.

3. Candidate's eligibility for admission

Candidate's eligibility for admission Candidate who has passed the B.Sc. degree in any Life Sciences [Microbiology/ Applied Microbiology/ Industrial Microbiology/ Botany/ Plant Sciences and Plant Biotechnology/ Zoology/ Biochemistry/ Bioinformatics/ Biology/Chemistry with Botany/ Zoology as Allied Subjects] of this university or an examination of any other university accepted by the syndicate as equivalent thereto shall be eligible for admission to M.Sc. Degree Course in Microbiology.

4. Duration of the programme

The duration of the course is for two academic years consisting of four semesters.

5. CBCS structure of the program

Course Component	No. of courses	Hours of Learning/week	Marks	Credits
Part A (Credit Courses)				
Core courses	08	80	100	46
Skill development course	04	40	50	24
Skill Enhancement Course	02	20	100	08
Internal Elective (IE) Course	02	20	100	6 (For each internal elective)
External Elective Course (EE)	02	36	50	8
Research	-	-	200	8
Part B (Self-Learning Credit Courses)				

Elective Foundation courses	3	36	50	6
Total	25	256	650	106

6. CBCS- Scheme of Examinations semester wise structure

CHOICE BASED CREDIT SYSTEM (CBCS) COURSE STRUCTURE
M.Sc., INDUSTRIAL MICROBIOLOGY SYLLABUS 2020-21

Semester I (Previous) 15 Weeks

Subject Code	Subject Type	Paper Title	Instruction Hours / Week		Total IH	Credits		Total Credits	Examination Maximum Marks					Total Marks
									Theory			Practicals		
			Th	Pra		Th	Pra		IA	EA	Tot	EA	Tot	
IMB 101	CC	Basics of Microbiology	4	5	9	4	2	6	20	80	100	50	50	150
IMB 102	CC	Principles of Immunology	4	5	9	4	2	6	20	80	100	50	50	150
IMB 103	CC	Fundamentals of Biochemistry	4	5	9	4	2	6	20	80	100	50	50	150
IMB 104	SC	Bioseparation Techniques & Biostatistics	4	5	9	4	2	6	20	80	100	50	50	150
Total			**16**	**20**	**36**	**16**	**8**	**24**	**80**	**320**	**400**	**200**	**200**	**600**
	FC	Communicative English	2		2	2		2			50			

Subject Type: CC – Core Course: Essential Course for the degree of M.Sc. Applied Microbiology.
FC –Foundation Course
SC – Skill Development Course

Semester II (Previous) 15 Weeks

Subject Code	Subject Type	Paper Title	Instruction Hours / Week		Total IH	Credits		Total Credits	Examination Maximum Marks					Total Marks
									Theory			Practicals		
			Th	Pra		Th	Pra		IE	EA	Tot	EA	Tot	
IMB 201	CC	Enzyme Technology	4	5	9	4	2	6	20	80	100	50	50	150
IMB 202	CC	Cellular Process	4	5	9	4	2	6	20	80	100	50	50	150
IMB 203	SC	Food Safety & Quality Management	4	5	9	4	2	6	20	80	100	50	50	150
IMB 204	IE	Immuno Technology & Molecular Signalling / Diagnostics Microbiology / Bioinformatics	4	5	9	4	2	6	20	80	100	50	50	150
Total			**16**	**20**	**36**	**24**	**40**	**24**	**80**	**320**	**400**	**100**	**200**	**600**
	FC	Foundation Course in Computer	2		2	2		2			50			

		Applications												

Subject Type: CC – Core Course: Essential Course for the degree of M.Sc. Applied Microbiology.
IE – Internal Elective: Choice to the students to opt for one paper
FC –Foundation Course&SC – Skill Development Course

Semester III (Final) **15 Weeks**

Subject Code	Subject Type	Paper Title	Instruction Hours / Week		Total IH	Credits		Total Credits	Examination Maximum Marks					Total Marks
									Theory			Practicals		
			Th	Pra		Th	Pra		IE	EA	Tot	EA	Tot	
IMB 301	CC	Recombinant DNA Technology	4	5	10	4	2	6	20	80	100	50	50	150
IMB 302	SC	Bioprocess Technology	4	5	10	4	2	6	20	80	100	50	50	150
IMB 303	SC (IE)	Bioremediation / Animal Pharmaceutical Biotechnology / Molecular and Immuno Diagnostic/MOOCS	4	5	10	4	2	6	20	80	100	50	50	150
IMB 304	CC	Research Methodology	2	-	2	2	-	2	-	50	50	-	-	50
	EE	External Elective	4		4			4	20	80	100	-	-	100
Total			**18**	**15**	**33**	**14**	**6**	**24**	**80**	**370**	**450**	**150**	**150**	**600**
	FC	Gender Studies and Self Defense	2		2	2		2			50			

EXTERNAL ELECTIVE

Subject Code	Subject Type	Paper Title	Instruction Hours / Week		Total IH	Credits		Total Credits	Examination Maximum Marks						Total Marks
									Theory			Practicals			
			Th	Pra		Th	Pra		IE	EA	Tot	IE	EA	Tot	
	EE	Public Health Communication	4		4			4	20	80	100	-	-	-	100

Subject Type: CC – Core Course: Essential Course for the degree of M.Sc. Applied Microbiology.
EE – External Elective: **Multi Disciplinary Course** offered and evaluated by Dept. of Applied Microbiology and Communication & Journalism Minimum strength to offer the course is 10 students.
FC –Foundation Course& EA – External Assessment
IE – Internal Elective: Choice to the students to opt for one paper & SC – Skill Development Course

Semester IV (Final) 15 Weeks

Subject Code	Subject Type	Paper Title	Instruction Hours / Week		Total IH	Credits		Total Credits	Examination Maximum Marks						Total Marks
									Theory			Practicals			
			Th	Pra		Th	Pra		IE	EA	Tot	IA	EA	Tot	
IMB 401	SE	Omic Tools for Microbial Bioprospecting	4	5	9	4	2	6	20	80	100	-	50	50	150
IMB 402	CC	Bio Engineering	4	5	9	4	2	6	20	80	100	-	50	50	150
IMB	SE	Techno	4	-	4	4	-	4	20	80	100	-	-	-	100

403		Entrepreneurship & Bioethics													
IMB 404	RC	Project	-	16	16	-	8	8	-	-	-	50	150	200	200
		Total	**12**	**26**	**38**	**12**	**12**	**24**	**60**	**240**	**300**	**50**	**250**	**400**	**600**
Total															**2400**
Total Credits: 24+24+24+24 = 96 Credits															

Subject Type: CC – Core Course: Essential Course for the degree of M.Sc. Applied Microbiology
SE – Skill Enhancement Course – (Online)
RC- Research based course

7. CBCS- Scheme of Examinations semester wise structure

Examinations

There shall be four semester examinations: first semester examinations at the middle of the first academic year and the second semester examination at the end of the first academic year. Similarly, the third and fourth semester examinations shall be held at the middle and end of the second academic year, respectively.

8. Scheme for Evaluation and Attainment Rubrics

Evaluation will be done on a continuous basis and will be evaluated with two internal exams, assignment and seminar in each semester.The end semester examination is a University theory examination with prescribed question paper pattern with two sections.

Attainment Rubrics for Theory Courses
External :80 Marks
Internal : 20 Marks
Total : 100 Marks
Time : 3 hours
Question Paper Pattern (Theory)
Section Approach Mark pattern

Section	Approach	Mark pattern
A	100 to 400 words (Answer any six questions)	4X5= 20 (analytical type questions)
B	1000 to 1500 words	5X12 =60 (Essay type questions)

The following procedure will be followed for Internal Marks:
Theory Papers Internal
Average of two tests: 10 marks
Seminar: 5 marks
Assignment: 5 marks
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20 marks

Attainment Rubrics for Lab courses

Practical : 50 external Marks

Practical Test : 40 marks
Record : 5 marks
Viva-voce : 5 marks

Attainment Rubrics for Research project

Internal Mark: 50 marks
External marks: 100 marks
Viva - voce: 20 marks
Project presentation: 20 marks
Project Report: 200 marks

10. Grading System

Evaluation of performance of students is based on ten-point scale grading system as given below.

	Ten Point Scale	
Grade of Marks	**Grade Point**	**Letter Grade**
75 - 100	7.5-10	O
65 – 74.9	6.5-7.49	A+
60 – 64.9	6.0-6.49	A
55 – 59.9	5.5-5.99	C
50 – 54.9	5.0-5.49	D
45 – 49.9	4.5-4.99	Pass
0 - 44	0-4.4	Fail
ABSENT	AAA	Absent

Course name	**Course outcome**	**LO 1**	**LO 2**	**LO 3**	**LO 4**	**LO 5**	**LO 6**	**LO 7**	**LO 8**	**LO 9**	**LO 10**
First Semester											
BASICS OF MICROBIOLOGY	Demonstrate theory and practical skills in microscopy and their handling techniques and staining	✓									
	Know General bacteriology and microbial techniques for isolation of pure cultures of bacteria, fungi. Master aseptic techniques and be able to	✓									

	perform routine culture handling tasks safely and effectively.										
	Know the various Physical and Chemical growth requirements of bacteria and get equipped with various methods of bacterial growth measurement.	✓									
	Master aseptic techniques and be able to perform routine culture handling tasks safely and effectively	✓									
PRINCIPLES OF IMMUNOLOGY	To provide students with knowledge on how the immune system works building on their previous knowledge from biochemistry, genetics, cell biology and microbiology		✓								
	Able to articulate the roles of innate recognition receptors (i.e. Toll-Like Receptors) in immune responses compare and contrast humoral		✓								

	versus cell-mediated immune responses.										
	Able to distinguish and characterize antibody isotypes, development, and functions, understand the role of cytokines in immunity and immune cell activation		✓								
	Understand the significance the Major Histocompatibility Complex in terms of immune response and transplantation, describe lymphocyte development and the expression of their receptors, an overview of hypersensitive reactions.		✓								
FUNDAMENTALS OF BIOCHEMISTRY	Overview on classification, structure and function of carbohydrates, lipids, proteins, amino acids and nucleic acids, biological significance of carbohydrates, lipids and nucleic acids in themetabolism			✓							
	Theoretical			✓							

	knowledge on biosynthesis and catabolism of carbohydrates, lipids and nucleic acids										
	Classification of proteins and structure of proteins primary, secondary, super secondary, tertiary and quaternary structures			✓							
	Specify the significance of urea cycle and ammonia assimilation in the Nitrogen catabolism.			✓							
	Specify the significance of urea cycle and ammonia assimilation in the Nitrogen catabolism.			✓							
BIOSEPARATION TECHNIQUES AND BIOSTATISTICS	Guide the students to select the most suitable technique that can be adapted for their Research projects; assist the students to undertake the correct sample preparation				✓						
	Design an analytical work flow to acquire the required data in fulfilling the research Objectives, provides the student with				✓						

	detailed scientific information about the instruments, their merits and limitations.										
	Motivates the students to choose relevant industries for their career based on their Interest in a particular technique, Preference will be given to the skilful students in appropriate techniques in food, pharmaceutical, chemical, dairy, industries, medical research field and other areas.				✓						
	To learn about various chromatographic and electrophoresis techniques in separation and purification of bio molecules, to learn how to and where to apply radioisotopes and molecular characterization of compounds by spectroscopy, biostatistics tools makes the students to interpret their experimental				✓						

	data in a systematic manner.										

Semester I (Core Course) **IMB 101**

BASICS OF MICROBIOLOGY

Course Objective:

The study of microbes helps us to understand our world and our place within it. It gives us insights into the complexity of nature and society, which in turn provide many different health, environmental, social, cultural, industrial and economic benefits.

Learning Outcomes:

- Demonstrate theory and practical skills in microscopy and their handling techniques and staining.
- Understand the basic microbial structure and function and study the comparative characteristics of prokaryotes and eukaryotes and also understand the structural similarities and differences among various physiological groups of bacteria/archaea.
- Know various Culture media and their applications and also understand various physical and chemical means of sterilization.
- Know General bacteriology and microbial techniques for isolation of pure cultures of bacteria, fungi. Master aseptic techniques and be able to perform routine culture handling tasks safely and effectively.
- Know the various Physical and Chemical growth requirements of bacteria and get equipped with various methods of bacterial growth measurement.

Unit	**Unit Title**	Intended Learning Chapters		**Hours of Instructions**
		KL & AL1	**AL2, EL & SL**	
Unit- I	**Principles of Microbiology**	History of Microbiology, Basis for the classification ;of Bacteria-morphological, biochemical,metabolic and molecular criteria.Major Taxonomical groups of bacteria. MB Diversity: General properties of		**12hrs**

		fungi, Mycoplasma (PPLO), Rickettsiae, Chlamydia, Actinomycetes, Archebacteria (extremophiles) and micro algae.		
Unit II	**Microbiological Techniques**	Sterilization and disinfection – physical and chemical methods. Mode of action of disinfectants. Preservation and maintenance of cultures. Methods	.Methods of testing disinfectants. Isolation of pure cultures.Cultivation of aerobic and anaerobic microbes, Media for growth of microorganisms (bacteria, fungi and algae). of identification of bacteria (Biochemical, Serological and Molecular Methods).	**12hrs**
Unit- III	**Cytology**	Structure of prokaryotic and eukaryotic cell. Comparison of the structure and function of each component of Eubacterial cell and Archaebacteria.	Biosynthesis of bacterial cell wall and Phases of cell division. Sporulation: Structure of bacterial endospores, physiology and genetics of sporulation.	**12hrs**
Unit IV	**Nutrition and Growth**	Nutritional groups of bacteria (autotrophy and heterotrophy). Bacterial growth curve and factors influencing growth.	Nutritional mutants - auxotrophs and their applications in metabolic studies, Carbon assimilation in bacteria, factors influencing growth (physical and chemical), Batch ,synchronous cultures and continuous culture methods. Methods for estimation of bacterial growth.	**12hrs**

Unit V	**Host parasite interactions**	pathogen-induced diseases in animals and plants, cell-cell fusion in both normal and abnormal cells.	Recognition and entry processes of different pathogens like bacteria, viruses into animal and plant host cells, alteration of host cell behavior by pathogens, virus-induced cell transformation,	

Reference:

1. Microbiology: An Introduction 13th Edition, 2018 by Gerard Tortora (Author), BerdellFunke (Author), Christine Case (Author), Derek Weber (Author), Warner Bair III (Author).
2. Microbiology: Laboratory Theory & Application, Brief 3rd Edition 3rd edition (January 1, 2016)by Michael J. Leboffe (Author), Burton E. Pierce (Author) Morton Publishing Company.
3. Prescott's Microbiology 10th Editionby Joanne Willey (Author), Linda Sherwood (Author), Christopher J. Woolverton (Author), Publisher : McGraw-Hill Education; 10th edition (January 4, 2016).
4. Brock Biology of Microorganisms (14th Edition) 14th Editionby Michael T. Madigan (Author), John M. Martinko (Author), Kelly S. Bender (Author), Daniel H. Buckley (Author), David A. Stahl (Author), Thomas Brock (Author), Publisher : Pearson; 14th edition (January 12, 2014).
5. Microbiology (Lippincott's Illustrated Reviews) 3rd Editionby Cynthia NauCornelissen (Author), Bruce D. Fisher (Author), Richard A. Harvey (Author), Publisher- Lippincott Williams & Wilkins; 3rd edition (October 12, 2012).
6. Foundations in Microbiology 10th Editionby Kathleen Park Talaro (Author), Barry Chess (Author), Publisher : McGraw-Hill Education; 10th edition (February 20, 2017).
7. Microbiology: Principles and Explorations 9th Editionby Jacquelyn G. Black (Author), Laura J. Black , Publisher : Wiley; 9th edition (August 10, 2015)
8. Ananthanarayana R. JayaramPanikar C.K. (2020), 11thed. A Text Book of Microbiology, Orient Longman.
9. Microbiology: Principles and Explorations, Jacquelyn G. Black, John Wiley &sons, 2015.
10. Foundations in Microbiology, Kathleen Park Talaro, Chess, McGraw-Hill education - 2014.
11. Topley and Wilson's Microbiology and Microbial Infections (Volume 1) Volume 1 Editionby W. W. C. Topley (Author), Graham S. Wilson (Author), Publisher : Wiley-Blackwell; Volume 1 edition (August 30, 2006).
12. Alcamo;s Fundamentals of Microbiology, JC Pommerville,9th edition-2016.

Semester I (Core Course) **IMB 102**

PRINCIPLES OF IMMUNOLOGY

Course objective:

Immunology is a diverse and growing discipline that can be defined as the study of the tissues, cells and molecules involved in host defence mechanisms. Immunologists attempt to understand how the immune system develops, how the body defends itself against disease, and what happens when it all goes wrong.

Course Outcomes:

- To provide students with knowledge on how the immune system works building on their previous knowledge from biochemistry, genetics, cell biology and microbiology.
- Be able to articulate the roles of innate recognition receptors (i.e. Toll-Like Receptors) in immune responses, compare and contrast humoral versus cell-mediated immune responses.
- Be able to distinguish various cell types involved in immune responses and associated functions, role of CD4+ T helper cell lineages Th1, Th2, Th17, and regulatory T cell.
- Be able to distinguish and characterize antibody isotypes, development, and functions, understand the role of cytokines in immunity and immune cell activation.
- Understand the significance the Major Histocompatibility Complex in terms of immune response and transplantation, describe lymphocyte development and the expression of their receptors, an overview of hypersensitive reactions.

Unit	Unit Title	Intended Learning Chapters		Hours of Instructions
		KL & AL1	**AL2, EL & SL**	
Unit- I	**Cells and organs of immune system**	History and Scope of Immunology: Haemopoeisis, lymphoid, mononuclear, granulocytic, mast and dendritic cells.Origin and organization of primary and	Cells and molecules involved in innate and adaptive immunityNon-specific immune factors, inflammation and phagocytosis, Nature and types of antigens, Haptens, antigen specificity, cross reactivity. Iso antigens, T-dependent and independent	**12hrs**

		secondary lymphoid organsTypes of immunity, and Adjuvants	antigens, Super antigens	
Unit II	**Microbiological Techniques**	Types, structure and properties of antibodies, Affinity and avidity of antibodies. Genetic events in the synthesis of immune globulin chains, organization and rearrangement of light chain and heavy chain genes, ,	Regulation of immunoglobulin synthesis – idiotypicnetwork , class or isotypeswitching of antibody diversity and immunoglobulin gene super family Cell types involved in cell mediated immunity. Cell-mediated effector functions Origin, biology and maturation of 'B' and T Lymphocytes (B-dependent and Tindependent)	**12hrs**
Unit III	**MHC and Immune response**	Immune response genes and Structure and function of MHC antigens	Role of MHC in controlling the T-cell response, MHC restriction. Triggering of immune response and tolerance Antigen processing and presentation, activation and differentiation of B and T cells, B and T cell receptors, Humoral and cell-mediated immune responses, primary and secondary immune modulation, clonal selection theory. Cytokines and their role inimmune regulation.	**12hrs**
Unit IV	**Complement and Antigen-Antibody interactions**	The complement system, Complement components, Biological activity of complement components,	Toll-like receptors, immune response during bacterial (tuberculosis), parasitic (malaria) and viral (HIV) infections, monoclonal antibodies, antibody engineering.	**12hrs**

		classical and alternate pathways	Antigen and antibody interactions: Agglutination, precipitation, complement fixation, neutralization. Immunoelectrophoresis, immunofluorescence FACS, ELISA, RIA and immunoblotting.	
Unit V	**Hypersensitivity reactions**		Antibody mediated type II, anaphylactic reactions, Antibody mediated, type II cytotoxic reactions, Immune complex reactions Type – III, T-cell mediated delayed type hypersensitivity Type-IV, Immunological tolerance and tolerance induction	

Reference:

1. Advanced Concepts in Human Immunology: Prospects for Disease Control: Prospects for Disease Control 1st ed. 2020 Edition by Pooja Jain (Editor), Lishomwa C. Ndhlovu (Editor), Publisher : Springer; 1st ed. 2020 edition (August 13, 2020).
2. Immunology: With STUDENT CONSULT Online Access 9th Editionby David Male MA PhD (Editor), R. Stokes Peebles Jr. MD (Editor), Victoria Male MA PhD (Editor), Publisher : Elsevier; 9th edition (July 15, 2020)
3. Oxford Handbook of Clinical Immunology and Allergy (Oxford Medical Handbooks) 4th Editionby Gavin Spickett (Author), Publisher : Oxford University Press; 4th edition (December 30, 2019)
4. Medical Immunology, 7th Edition 7th Editionby Gabriel Virella (Editor), Publisher : CRC Press; 7th edition (October 16, 2019)
5. IMMUNOLOGY Paperback – April 26, 2019by KANNAN I (Author), Publisher : MJP Publishers (April 26, 2019)
6. Basic Immunology: Functions and Disorders of the Immune System 6th Editionby Abul K. Abbas MBBS (Author), Andrew H. Lichtman MD PhD (Author), Publisher : Elsevier; 6th edition (April 24, 2019)
7. Immunology: An Introductory Textbook 1st Editionby Anil K. Sharma (Editor), Publisher : Jenny Stanford Publishing; 1st edition (March 5, 2019)
8. Cooper E.L. (1982) General Immunology, Pergamon press, N.Y.
9. Eli BenzaminiGeoffry sunshine, Sidneyleskowitz (1966) Immunology - a short course, 3rd edition, A John Wiley & Sons inc. publication
10. Nandinishetty (1999) Immunology introductory text book New Age international (p) Ltd. Publishers.

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12. Ivan M Roitt.1997 Essential Immunology 9th ed. Blackwell Scientific publ. Oxford.
13. Golub, E.S. (ed.) 1981. The cellular basis of the immune response, Sinauer Associates, Inc. Sunderland
14. Hobert, J. and Ian Mc Connell. The Immune system. Black well, 1986.
15. StitlesFudenberg. Basic clinical Immunology. 8th ed. Lange Medical Publ. USA.
16. Gooding, J.W. Honoclonal antibodies, Principles & Practice 2nd ed. London Academic press, 1986.
17. Nisonoff A (1984) : Introduction to Molecular Immunology, sunderland MA sinauer
18. Rose N.R. Friedman H. Fanay J (1986) : Manual of Clinical Immunology 3rd ed. Washington D.C. American society of Microbiology.
19. Weir D.M. (1986) Hand book of Experimental Immunology, Vol. 12, 4th ed. Oxford Blackwell Scientific publications
20. Hadson L, Italy FC (1989) Practical Immunology 3rd ed. Oxford: Blackwell Scientific Publications.
21. Immunology Janis Kuby, 2000

Semester I (Core Course) **IMB 103**

FUNDAMENTALS OF BIOCHEMISTRY

Course Objective:

Biomolecules are the molecules or ions present in an organism that are essential for the biological processes such as growth, development, cell division, etc. Biomolecules include large molecules or macromolecules such as proteins, carbohydrates, lipids, and nucleic acids, whereas the smaller molecules or macromolecules include metabolites and natural products.

Course Outcomes:

- Overview on classification, structure and function of carbohydrates, lipids, proteins, amino acids and nucleic acids, biological significance of carbohydrates, lipids and nucleic acids in the metabolism
- Theoretical knowledge on biosynthesis and catabolism of carbohydrates, lipids and nucleic acids
- Classification of proteins and structure of proteins - primary, secondary, super secondary, tertiary and quaternary structures
- Specify the significance of urea cycle and ammonia assimilation in the Nitrogen catabolism.
- Explain the Structure, function of enzymes, enzyme kinetics and their allosteric regulation and Catalytic Mechanism of Lysozyme and chymotrypsin and immobilised enzymes, hands on training, on Qualitative and quantitative detection of biomolecules and enzyme kinetics

Unit	Unit Title	Intended Learning Chapters		Hours of Instructions
		KL & AL1	**AL2, EL & SL**	
Unit- I	**Carbohydrates**	classification and metabolism,	Glycolysis, TCA cycle, Glyoxylate cycle, H.M.P. gluconeogenesis ,Phosphoketolase and ED-pathway .	**12hrs**
Unit II	**Oxidative phosphorylation andLipids**	Lipids-Classification, β ,α, Omega-oxidations and biosynthesis of fatty acids.	Oxidative phosphorylation and its coupling to electron transport, biological energy transducers, uncouplers and inhibitors of ETC	**12hrs**
Unit III	**Nucleic Acids**	Nucleic acids: Structure of purines, pyrimidines and their analogues derivatives	Poly Nucleotide withinternucleotide (phosphodiester bond) linkage. Biosynthesis of purine and pyrimidine nucleotides.Biosynthesis ofdeoxy - ribonucleotides, Catabolism of nucleotides	**12hrs**
Unit IV	**Amino Acids& Proteins**	Proteins: Structural organization of proteins – (primary, secondary, tertiary and quarternary level)	Transamination, oxidative deamination, urea cycle, ammonia transport. Ramachandran plot, Denaturation of proteins.	**12hrs**
Unit V	**Enzymes**	Enzymes – classification, nomenclature, kinetics of enzymes – catalyzed reactions, Activators, proenzymes, coenzymes,	Michaelis- Menten equation, determination of Vmax, K_M K_{cat} specificity constant kcat/kM and their significance. Effect of pH, temp, concentration of enzyme and conc. of substrates on rate of enzyme – catalyzed	**12hrs**

		isoenzymes, Abzymes and Ribozyme.	reactions,Catalytic function of Lysozyme and chymotrypsin. Enzyme inhibition: reversible inhibition – competitive, uncompetitive, non competitive allosteric and irreversible inhibition.	

Reference

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3. Biochemistry Ninth Editionby LubertStryer (Author), Jeremy M. Berg (Author), John L. Tymoczko (Author), Gregory J. Gatto Jr. (Author), Publisher : W. H. Freeman; Ninth edition (January 25, 2019)
4. The Physiology and Biochemistry of Prokaryotes 2012 .David white. Oxford University Press, Newyork
5. Zubay, Biochemistry, 2014,. William c. Brown Publication
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Semester I (Skill Development Course) **IMB 104**

BIOSEPARATION TECHNIQUES AND BIOSTATISTICS

Course Objective:

Analytical technique is a method that is used to determine a chemical or physical property of a chemical substance, chemical element, or mixture. There are a wide variety of techniques used for analysis, from simple weighing to advanced techniques using highly specialized instrumentation. Statistical analysis define the type and quantity of data need to be

collected. Organizing and summarizing the data. Analyzing the data and drawing conclusions from it.

Course Outcomes:

- Guide the students to select the most suitable technique that can be adapted for their Research projects; assist the students to undertake the correct sample preparation.

- Design an analytical work flow to acquire the required data in fulfilling the research Objectives, provides the student with detailed scientific information about the instruments, their merits and limitations.

- Ensure students to write their methodology and justification for choosing the technique in their research work in their scientific publications, to learn the basic microbial techniques like different types of microscopy, electrochemical techniques and centrifugation, and their applications in diverse fields.

- To learn about various chromatographic and electrophoresis techniques in separation and purification of bio molecules, to learn how to and where to apply radioisotopes and molecular characterization of compounds by spectroscopy, biostatistics tools makes the students to interpret their experimental data in a systematic manner.

- Motivates the students to choose relevant industries for their career based on their Interest in a particular technique, Preference will be given to the skilful students in appropriate techniques in food, pharmaceutical, chemical, dairy, industries, medical research field and other areas.

Unit	**Unit Title**	**Intended Learning Chapters**		**Hours of Instructions**
		KL & AL1	**AL2, EL & SL**	
Unit- I	**Electrochemical and Microscopic Techniques**	Principles of biophysical chemistry (pH, buffer, reaction kinetics, thermodynamics, colligative properties methods for EM,Cryo electron microscopy andConfocal microscopy.	Visulization of cells and subcellular components by light microscopy, resolving powers of different microscopes, microscopy of living cells, scanning and transmission microscopes, different fixation and staining techniques for EM, freeze-etch and freeze-fracture	**12hrs**
Unit II	**Centrifugation**	Basic principle of centrifugation technique- Different types of	Role of centrifugation in separation of cellular fractions, viruses and	**12hrs**

		rotors and centrifuges and their applications.- Preparative and analytical ultra centrifugation- Differential and Density gradient methods.	macromolecules.	
Unit III	**Chromatography and Radio Labeling**	Principles of chromatography	Thin layer, paper, ion exchange, gel permeation, High Performance Liquid Chromatography, Gas Chromatography and affinity chromatography with examples Applications of Radioactive and Non-radio active labeling.	**12hrs**
Unit IV	**Electrophoresis and Spectroscopy**	Eletrophoresis – Basic principle and types- Paper/cellulose acetate, gel electrophoresis- starch gel,	SDS PAGE, Agarose and isoelectric focussing, Types of blotting techniques. Spectroscopy: UV/Visible, fluorescence, IR.Fundamentals of X-ray diffraction , NMR, Mass spectroscopy and Flow Cytometry.	**12hrs**
Unit V	**Statistical Methods**		Measures of central tendency: mean, median, mode, probability distributions(Binomial, Poisson and normal); Sampling distribution; Confidence Interval; Errors; Levels of significance; Regression and Correlation; t- test, chi square test; Analysis of variance, Measures of Dispersion	

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2. G. Cooper 2011 Tools of Biochemistry, Volume 2.Wiley publications.
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6. A. Skoog, F.J. Halter and T.A. Niemen, 2018 Principles of Instrumental Analysis Revised 7thed. Harvest College Publications, Amsterdam
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PRACTICAL 1 (Core Practical)
Basics of microbiology & Bioseparation techniques and Biostatistics

BASICS OF MICROBIOLOGY

1. Sterilization techniques – autoclaving, heat sterilization, filtration, UV irradiation and chemical
2. Preparation of Media
3. Staining techniques in bacteria Simple, differential and special staining, spore, capsule, Flagella
4. Isolation and cultivation of pure cultures
5. Techniques of maintenance of stock cultures
6. Anaerobic culturing of bacteria
7. Testing the efficiency of disinfectant action, Dettol, phenol (Reidel – Walker test)
8. Growth curve and generation time in bacteria
9. Effect of Temperature & P^H on the growth of bacteria
10. Cultivation of autotrophic and heterotrophic organisms.

BIOSEPARATION TECHNIQUES AND BIOSTATISTICS

1. Measurement of pH in biological fluids
2. Separation of biomolecules by paper chromatography
3. Separation of amino acids, carbohydrates and lipids from different biological samples by thin layer chromatography
4. Separation of organo pollutants by HPLC technique
5. Purification of proteins by gel filtration chromatography
6. Separation of amino acids by paper electrophoresis
7. Polyacrylamide gel electrophoresis of proteins
8. Agarose gel electrophoresis of DNA
9. Absorption spectra of tyrosine and tryptophan
10. Isolation and spectrophotometric determination of cyanobacterial/plant pigments
11. Statistical Analysis using Graph pod/sig

Unit	**Unit Title**	**Intended Learning Chapters**		**Hours of Instructions**
		KL & AL1	**AL2, EL & SL**	
Unit- I	Sterilization and Staining Techniques	autoclaving, heat sterilization, filtration, UV irradiation and chemical. Media preparation.	Gram Staining Metachromatic granular Staining Spore Staining Capsule Staining Flagella staining Lactophenol Cotton Blue Staining Motility Test Fungal Slide Culture	**12.5 hrs**
Unit II	Biochemical Test & Bacterial metabolism		Testing the efficiency of disinfectant action, Dettol, phenol (Reidel – Walker test) Growth curve and generation time in bacteria Effect of Temperature & P^H on the growth of bacteria. Cultivation of autotrophic and heterotrophic organisms.	**12.5 hrs**
Unit III	Growth of microorganims	Isolation and cultivation of pure		**12.5 hrs**

		cultures Techniques of maintenance of stock cultures. Anaerobic culturing of bacteria		
Unit IV	Statistical Analysis and pH measurement	Measurement of pH in biological fluids	Statistical Analysis using Graph pod/sig	**12.5 hrs**
Unit V	Adsorption chromatography & Column chromatography		Separation of biomolecules by Paper, TLC, HPTLC and Gel filteration chromatography	**12.5 hrs**
Unit VI	Electrophoresis and spectrophotometric techniques	Separation of aminoacids by paper electrophoresis. Absorption spectra of DNA, RNA, Tyrosine and Trypatophan	Separation and purification of DNA and proteins by agarose and SDS-PAGE. Isolation and separation of plant pigments.	**12.5 hrs**

PRACTICAL 2 (Core Practical)
Principles of Immunology & Fundamentals of Biochemistry

PRINCIPLES OF IMMUNOLOGY

1. Blood typing – A, B, O and Rh system
2. Enumeration of R.B.C
3. Enumeration of WBC
4. Differential Leukocyte count
5. Separation of serum and plasma
6. Lymphocyte separation and identification of viable lymphocytes.
7. Preparation of adjuvants
8. Precipitation test – Immunodiffusion, Radial immuno diffusion
9. Enumeration of `T` and `B` cells by rosette formation
10. Fluorescent antibody technique
11. Leucocyte migration and inhibition

FUNDAMENTALS OF BIOCHEMISTRY

1. Qualitative tests for carbohydrates and identification of unknown carbohydrates.

2. Qualitative tests for amino acids and Proteins.
3. Qualitative tests for Lipids.
4. Qualitative tests for Nucleic acids.
5. Estimation of sugar and glucose by Benedicts and DNS method.
6. Estimation of protein by Biuret, Lowry method. UV absorption.
7. Estimation of cholesterol, blood urea, creatinine
8. Qualitative analysis of lipids
    a) Saponification value of fat.
    b) Determination of iodine value in oil.
9. Determination of characteristics of Enzyme catalysed reaction Vmax and K_M
10. Effect of Temperature and pH on the rate of enzyme catalyzed reaction.
11. Isolation of acid and alkaline phosphatase.

Unit	**Unit Title**	**Intended Learning Chapters**		**Hours of Instructions**
		K1 & K2	**K3, K4 & K5**	
Unit- I	Agglutination Tests	Blood typing – A, B, O and Rh system		**12.5 hrs**
Unit II	Haematology	Separation of serum and plasma	Enumeration of RBC & WBC Differential Leukocyte count	**12.5 hrs**
Unit III	Precipitation test		Immunodiffusion, Radial immuno diffusion. Rocket immune electrophoresis	**12.5 hrs**
Unit IV	Qualitative Tests	Knows the presence of sugars, aminoacids and lipids		**12.5 hrs**
Unit V	Quantitative Tests		Estimates the amount of sugars, aminoacids and lipids in the given sample.	**12.5 hrs**
Unit VI	Enzyme kinetics	Determination of characteristics of Enzyme catalysed reaction	Effect of temperature and pH in Enzyme catalysed reaction Isolation of acid and alkaline phosphatase.	**12.5 hrs**

Course name	**course**	**L**	**L**	**LO**	**LO**	**LO**	**LO**	**LO**	**LO**	**LO**	**LO**

	outcome	O1	O 2	3	4	5	6	7	8	9	10
Second Semester											
ENZYME TECHNOLOGY	The course provides the theory and knowledge relevant to the enzymology principles including fundamental properties of enzymes, enzyme catalytic mechanisms and Enzyme kinetics.			✓							
	Compare methods for production, purification, characterization and immobilization of enzymes.			✓	✓						
	Students will also be introduced to the theory as well as applications of enzyme technology in food, medical, and household industries.			✓							
	Apply biochemical calculation for enzyme kinetics and plot graphs based on kinetics data.			✓							
	Discover the current and future trends of applying enzyme technology for the commercialization purpose of biotechnological products.			✓						✓	
CELLULAR PROCESS	To study the major Biomolecules regulating the cell at molecular level based on the knowledge gained basic core papers	✓		✓		✓					
	Understand the										

	replication of DNA and comparison between replication of prokaryote and eukaryote organism.Discuss the molecular mechanisms of mutations and DNA repair, basic understanding of horizontal gene transfer with special emphasis on Conjugation, Transformation and Transduction.										
	Gain knowledge of basic mechanism of transcription and translation and distinguish the process in prokaryote and eukaryote organism	✓				✓					
	Articulate the mechanism of gene regulation in prokaryotic and eukaryote organism with comparison. Elucidate the concept of recombination and bacterial chromosomal mapping					✓					
	Understand DNA interacting protein and important domains which confer the activity. Significance of Plasmids and Transposons in microbial genetics. Gain practical Skills independently in purification, handling of DNA.					✓					
FOOD	Acquire an	✓	✓	✓		✓	✓		✓		✓

SAFETY &Quality Management	understanding of relevance of food components,										
	Acquire an understanding of application and detection techniques in food.	✓	✓	✓				✓			✓
	Apply regulatory techniques in real time scenarios	✓		✓	✓		✓				✓
	Acquire an understanding in industrial operations in food, role of microbes	✓	✓		✓		✓		✓		✓
IMMUNO TECHNOLGY & MOLECUAL R SIGNALLING (Internal Elective)	Understand the structure and function at the molecular and cellular level of the immune defence, provide the knowledge about the transfusion and transplantation immunological reactions able to provide an overview for polyclonal, monoclonal and humanized antibodies and production of hybridoma		✓								
	Discern the replication strategies of representative viruses from the seven Baltimore classes, Principles of virus structure.						✓				
	Various methods of virus cultivation, alterations in the genetic material of a virus -such changes										

	may result in the creation of new viral serotypes or viruses of altered virulence.										
	Stages of mitosis and meiosis highlighting similarities and differences, understand the cancer and cell cycle.								✓		
	Understand the basic principles of signal transduction mechanisms, in particular the concepts of response specificity, signal amplitude and duration, signal integration and intracellular location					✓					
DIAGNOSTIC MICROBIOLOGY	To study the Main characteristics of medically important microbes and to teach aseptic techniques, to provide understanding of microbial agents like Sterilization, Disinfection, antisepsis.	✓			✓						
	To determine the activity of biocide, Germicide, Bacteriostatic, and asepsis by theoretical method, upon completion of this subject, the student will be able to evaluate information about careers.	✓			✓						
	Learn about bacterial pathogenesis and diagnosis of urine,	✓					✓				

	blood, CSF, sputum and swab and genital swab.										
	To learn about antimicrobial techniques and microbial resistance etc	✓			✓						
	Students gain practical experience in diagnosis of pathogens found in clinical specimens, Treatment of infectious diseases by antimicrobial agents.	✓			✓						
BIOINFORMATICS	Aimed to provide an overview of various bioinformatics tools, databases available and sequence analysis.			✓							
	Retrieve information from available databases and use them for microbial identifications.										
	Provide knowledge on database concept, management, retrieval along with utilization in gene and protein analysis. Protein Structure and prediction Molecular Modeling and docking.					✓					
	Gain ability to modify gene and protein structures in simulated systems.					✓					
	Develop competence to retrieve information from biological databases and integrate these					✓					

	biological information with computational software										

Semester II (Core Course) **IMB 201**

ENZYME TECHNOLOGY

Course Objective:

Enzyme technology is one of the corner stones of Industrial Biotechnology. The research in this area involves both fundamental and applied enzymology, biocatalysis, molecular modelling, structural biology and diagnostics. Enzymes are employed in a diverse array of applications in industries and scientific research, ranging from the degradation of various natural substances in the starch processing, detergent and textile industries

Learning Outcomes:

- The course provides the theory and knowledge relevant to the enzymology principles including fundamental properties of enzymes, enzyme catalytic mechanisms andenzyme kinetics.
- Compare methods for production, purification, characterization and immobilization of enzymes.
- Students will also be introduced to the theory as well as applications of enzyme technology in food, medical, and household industries.
- Apply biochemical calculation for enzyme kinetics and plot graphs based on kinetics data.
- Discover the current and future trends of applying enzyme technology for the commercialization purpose of biotechnological products.

Unit	**Unit Title**	**Intended Learning Chapters**		**Hours of Instructions**
		KL & AL1	**AL2, EL & SL**	
Unit- I	**Enzyme**	General characteristics, classification and nomenclature, methods of enzyme Non protein enzymes – Ribozymes.	isolation and purification. Methods of enzyme assay, Enzyme units, specific activities and turnover number. Structure of Active site.	**12hrs**
Unit II	**Enzyme Kinetics**	Pre steady state and steady state kinetics. Fast kinetics -flow and relaxation methods effect of pH,	Michaelis –Menten plot, linear transformation – Lineweaver – Burk plot. Eadie – Hofstee plot,	**12hrs**

		temperature, enzyme and substrate concentration.	and Hanes – Wolf equation.Significance of Km and Vmax.Kinetics of allosteric enzymes, MWC and KNF models. Hill's equation and co-efficient.Bisubstrate reactions.	
Unit III	**Enzyme Inhibition Mechanism of enzyme action**	Irreversible and reversible, competitive, non competitive, uncompetitive, mixed inhibition, Suicidial inhibition-Kenetic differentiate and graphical methods.	Clinical uses of competitive inhibition using PABA, methotrexate, methanol poisoning and insecticides poisoning. **:**Acid base catalysis, covalent catalysis, strain, proximity and orientatior effects. Mechanism of action of lysozyme, chymotrypsin, ribonuclease and carboxypeptidase.	**12hrs**
Unit IV	**Coenzymes**	Multienzyme complexes – functions PDH, $FADH_2$**,** CoAfunctions.Metal dependent and metalloenzymes. Zymogen	Covalent modification of enzymes. Allosteric regulation of Aspartate transcarbamylase.	**12hrs**
Unit V	**Immobilized Enzymes**	Methods of immobilization application of immobilized enzymes.	Enzyme Engineering-Modification in the structure and active site of enzymes Industrial Enzymology**:** Amylases, glucose isomerases, cellulose degrading enzymes,	**12hrs**

			pectic enzymes, lipases, proteolytic enzymes in meat and leather industry, detergents and cheese production	

References:

1. Enzyme Technology Paperback – 28 February 2012by S. Shanmugam **(Author),** T. Sathishkumar **(Author),** M. Shanmugaprakash**,**
   Publisher : I K International Publishing House Pvt. Ltd; 2nd Revised edition (28 February 2012)
2. Enzymology and Enzyme Technology Paperback – 3 March 2014by Bhatt S.M. **(Author),**
   Publisher : S Chand & Company (3 March 2014)
3. Marangoni AG. Enzyme Kinetics. 2010, A Modern Approach John Wiley and Sons.
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12. Principles of Biochemistry – Lehninger, Nelson and Cox, 2013, WH Freeman and Company, New York, USA
13. Industrial enzymes and their applications,UhlingH.,John Wiley
14. Dixon and Webb. Enzymes 2009. Longmans.

Semester II (Core Course) **IMB 202**

CELLULAR PROCESS

Course Objective:

Molecular biology deals with nucleic acids and proteins and how these molecules interact within the cell to promote proper growth, division, and development. It is a large and ever-

changing discipline. This course will emphasize the molecular mechanisms of DNA replication, repair, protein synthesis etc.Molecular biology pertains to the study of living systems at the molecular level, especially DNA and RNA, and provides a background for further work in the rapidly expanding areas of genomics, cell biology, biotechnology, microbiology, diagnostics, and therapeutics

Learning Outcomes:

- To study the major Biomolecules regulating the cell at molecular level based on the knowledge gained basic core papers
- Understand the replication of DNA and comparison between replication of prokaryote and eukaryote organism. Discuss the molecular mechanisms of mutations and DNA repair, basic understanding of horizontal gene transfer with special emphasis on Conjugation, Transformation and Transduction.
- Gain knowledge of basic mechanism of transcription and translation and distinguish the process in prokaryote and eukaryote organism
- Articulate the mechanism of gene regulation in prokaryotic and eukaryote organism with comparison. Elucidate the concept of recombination and bacterial chromosomal mapping.
- Understand DNA interacting protein and important domains which confer the activity. Significance of Plasmids and Transposons in microbial genetics. Gain practical Skills independently in purification, handling of DNA. RNA and protein

Unit	**Unit Title**	**Intended Learning Chapters**		**Hours of Instructions**
		KL & AL1	**AL2, EL & SL**	
Unit - I	**Genetic Material & Mutations**	Nature of Genetic material: Evidence to prove DNA & RNA as genetic material. DNA repair**:** Photo reactivation, Excision repair, post replication, recombination and SOS repair mechanisms.	Organization of genome in Prokaryotes and Eukaryotes. Mutations: Types of mutations, molecular basis of mutations, mutagenic agents, Evaluation of mutagens by Ames test. Site directed mutagenesis and its applications.	**12hrs**
Unit II	**Genetic transfer &Recombination**	Plasmids and Transposons: Types of plasmids, Natural and artificial methods of	Mechanism of genetic transfer in bacteria Transformation,	**12hrs**

		plasmid transfer, their significance and applications,Transposable elements in prokaryotes and eukaryotes, types of bacterial transposons – Insertional sequences, complex transposons,	Transduction, conjugation, mapping of bacterial chromosome by transformation, conjugation and Transduction Recombination: Homologous recombination, role of Rec proteins in recombination Mechanisms of transposition (Replicative and non replicative).	
Unit III	**DNA Replication**	colE1 plasmid, ϕ x174 and yeast chromosomal DNA significance of telomerases, synthesis of telomers.	Replication of DNA, Mechanism and enzymology of replication.fidelity of replication, extrachromosomal replicons, Models of replication of DNA, Replication of E.coli chromosome	**12hrs**
Unit IV	**RNA synthesis, Processing and Regulation**	structure and function of different types of RNA, RNA transport	RNA synthesis - (transcription factors and machinery, RNA polymerases, Mechanism of transcription and inhibitors of transcription. Post transcriptional modifications - Nuclear splicing capping, elongation, and termination, RNA processing, RNA editing, splicing, and polyadenylation, Control of gene expression at transcription and translation level. Regulation of Gene Expression in prokaryotes.Levels of	**12hrs**

			regulation, clustered genes, operon and regulon concept, Negative and positive regulation of gene expression.Regulation of lac, arabinose, tryptophan operons. Global regulatory responses, stringent response of regulation in small molecules such as ppGpp .	
Unit V	**Protein Synthesis and Processing**	structure of ribosomes, aminoacyltRNAsynthetase Structure and function of signal peptide, signal hypothesis and protein trafficking	Translation: Genetic code deciphering, types of RNA and their role in protein synthesis, mechanism of protein synthesis, translational proof-reading, inhibitors of protein synthesis, post translational modifications. Protein localization and translocation:.	**12hrs**

Reference:

1. William Hayes, Genetics of Bacteria and their viruses CBS Publisher, 2011
2. B. Lewin Gene X Oxford press, 2011
3. J.W. Dale, Molecular Genetics of Bacteria, 2006
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7. Jogdand, S.N. Gene Biotechnology, Himalaya Publishing house,. 2010
8. Essential Cell Biology Fifth Editionby Bruce Alberts (Author), Karen Hopkin (Author), Alexander D. Johnson (Author), David Morgan (Author), Martin Raff (Author), Keith Roberts (Author), Peter Walter (Author), Publisher : W. W. Norton & Company; Fifth edition (July 1, 2019).

9. Molecular Biology of the Cell (Sixth Edition) Sixth Editionby Bruce Alberts (Author), Alexander D. Johnson (Author), Julian Lewis (Author), David Morgan (Author), Martin Raff (Author), Keith Roberts (Author), Peter Walter, Publisher : W. W. Norton & Company; Sixth edition (November 18, 2014)
10. Molecular Cell Biology Eighth Editionby Harvey Lodish (Author), Arnold Berk (Author), Chris A. Kaiser , Publisher : W. H. Freeman; Eighth edition (April 1, 2016)
11. Benjamin Lewin Genes X. Oxford University Press, New York, 2011.
12. David Freifelder George M. Malacinik, Essentials of Molecular Biology, Panima, 2012
13. G. Karp, Cell and Molecular Biology Concepts and Experiment, John Wiley, 1996.
14. W.H. Elliott and D C.Elliott, Biochemistry & Molecular Biology, Oxford University
15. Press, 2012
16. L. Stryer, Biochemistry, Freeman & Company, 2013
17. ShivaramaSastry, Text Book of Molecular Biology, Macmillan India 2004
18. M.Morange, Molecular Biology, Oxford University Press, 1999

Semester II (Skill Development Course) IMB 203

FOOD SAFETY AND QUALITY MANAGEMENT

COURSE OBJECTIVES

To prepare graduates for careers in the national and international food chain, e.g. food businesses, consultancy, research and development. To equip graduates with the knowledge and skills that will enhance their employability. To enrich graduates understanding of the dynamics of food safety and quality management systems and the context under which they operate at national and international levels.

Learning outcomes

Explain the application of food quality and food safety system
Identify the hazard of the food chain to ensure food safety
Examine the chemical and microbiological quality of food samples
Detect the adulteration in food samples
Review of legislative approaches for the management of food safety

SYLLABUS

Unit	Unit title	Intended Learning Chapters		Hours of Instruction
		(K1, K2)	(K3, K4 &K5)	
I	**Microbiology of foods**	Microbiology of foods and food safety. Factors affecting the	Role of microorganisms in fermented foods and	12

		growth of microorganisms in food	food industry. Economically important fermentation products	
II	**Food safety**	Food safety and importance of safe food. Factors affecting food safety – Physical, Chemical and Biological. Recent concerns of food safety	Food safety and food service establishments – food safety measures – hygiene and sanitation in food service establishments, licensing and sale.	12
III	**Food adulteration**	Food adulteration – common adulterants, classification of adulterants	Harmful effects of adulterants – methods for detection of adulterants.	12
IV	**Food packaging**	Food packaging – significance and function – classification of packaging material – packing methods – interaction between packaging and food – toxicity hazards. Packaging laws and regulations.	Biodegradable materials and environmental issues – labeling requirements, nutritional labeling and coding of foods.	12
V	**Risk analysis**	Risk analysis – HACCP – A food safety assurance system, Food regulations	Food regulations, standards and quality control. Prevention of food adulteration. Consumer protection Act, 1986 – regulations related to genetically modified foods.	12

REFERENCES

TEXT BOOKS

1. Food Microbiology (5th ed.) 2017. by W.C. Frazier & D.C. Tata Mc Graw Hill publishing house, New Delhi..

2. Adams, M.R. Food Microbiology fundamentals & Frontiers 2018 American .Society for Microbiology.5th ed. Washington. D.C.

3. James M.Jay.5th ed.2006. Modern food Microbiology. Food Science text series.

Semester II (Internal Elective) **IMB 204**

IMMUNO TECHNOLGY & MOLECUALR SIGNALLING

Course Objective:

Immunotechnology focuses on the use of body defence system for the production of immunological agents and diagnosis of several diseases that protect living beings from these diseases. The regulation of immune cells occurs through a number of key signaling pathways. Each pathway is comprised of a complex network of proteins that interact with one another to induce a specific cellular response to stimuli.

Course Outcomes:

- Understand the structure and function at the molecular and cellular level of the immune defence, provide the knowledge about the transfusion and transplantation immunological reactions able to provide an overview for polyclonal, monoclonal and humanized antibodies and production of hybridoma
- To gain a deep knowledge about the auto immune diseases and Immune deficiency disorders, describe immunization/vaccination, immunological disease and immunotherapy.
- Discuss immunological techniques and their applications in biotechnical industry, the key roles of mitosis and meiosis during the life cycle. Compare and contrast different life cycle strategies, focusing on the human life cycle.
- Stages of mitosis and meiosis, highlighting similarities and differences, understand the cancer and cell cycle.
- Understand the basic principles of signal transduction mechanisms, in particular the concepts of response specificity, signal amplitude and duration, signal integration and intracellular location

Unit	Unit Title	Intended Learning Chapters		Hours of Instructions
		KL & AL1	**AL2, EL & SL**	
Unit - I	**Cell cycle and Cancer biology**	Mitosis and meiosis, their regulation, steps in cell cycle, and control of cell cycle. Check points in cell cycle, regulation and control of cell cycle, inhibitors.	Genetic rearrangements in progenitor cells, oncogenes, tumor suppressorgenes, cancer and the cell cycle, virus-induced cancer, metastasis, interaction of cancer cells with normal cells, apoptosis,	**12hrs**

			therapeutic interventions of uncontrolled cell growth.	
Unit II	**Cell signaling and Quorum sensing**	Hormones and their receptors, cell surface receptor, signalingthrough G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, bacterial and plant two-component signaling systems. **C**hemotaxis	Role of acyl homolactone serine in quorum sensing, types of quorum sensing, regulation of quorum sensing, cell signaling in myxobacteria.	**12hrs**
Unit III	**Autoimmunity and Hybridoma Technology**	Immunodeficiency disorders Hybridoma technology: Production, purification and characterization of monoclonal antibodies.	Pathogenesis of auto immune disease, Disease with positive HLA associations, systemic lupus erythematus, multiple sclerosis, rheumatold arthritis, auto – immune haemolyticanaemia , Myasthenia gravis, graves disease, Type 1 Diabetes Mellitus, Hashimotos thyroiditis, treatment of auto immune disease. Application of monoclonals in biomedical research, clinical diagnosis, treatment and drug targeting.	**12hrs**
Unit IV	**Transfusion and Transplantation immunology**	ABO system, Rh antigens, Rh disease, MN blood group, Kell and duffy blood groups,	Selection of donors by cross matching. Transfusion reactions – Haemolytic, febrile	**12hrs**

		Relationship between donor and recipient, immune response to graft rejection, clinical characteristics of allograft rejection.	and allergic reactions. Transfusion transmitted infections. Transplantation antigens. MHC class I & II as targets of graft rejection, Tests for histocompatability antigens, prolongation of allografts, graft versus host disease.	
Unit V	**Immunoprophylaxis**	Types of vaccines – Conventional (BCG, Salk, Influenza, DPT) DNA vaccines, Glycoconjugatevanccines, Deletion vaccines, DC based vaccines, basis of attenuation.	Recent developments in vaccine technology, Vaccine delivery system and approaches to enhance immunogenicity, immunomodulators and immunomodulation, adjuvant, cytokines / interleukins based immune therapy	**12hrs**

References

1. Basic Immunology: Functions and Disorders of the Immune System 6th Editionby Abul K. Abbas MBBS (Author), Andrew H. Lichtman MD PhD (Author), Shiv Pillai MBBS PhD (Author), Publisher : Elsevier; 6th edition (April 24, 2019)
2. Roitt's Essential Immunology (Essentials) 13th Editionby Peter J. Delves (Author), Seamus J.

Martin (Author), Dennis R. Burton (Author), Ivan M. Roitt (Author), Publisher : Wiley-Blackwell; 13th edition (January 17, 2017)

3. Introductory Immunology, 2nd: Basic Concepts for Interdisciplinary Applications 2nd Edition, Publisher : Academic Press; 2nd edition (February 27, 2019)
4. Clinical Immunology: Principles and Practice 5th Editionby Robert R. Rich MD (Author), Thomas A Fleisher MD FAAAAI FACAAI (Author), William T. Shearer MD PhD (Author), Harry Schroeder (Author), Anthony J. Frew MD FRCP (Author), Cornelia M. Weyand MD PhD, Publisher : Elsevier; 5th edition (March 27, 2018)
5. Hancock, J. T. Cell signalling. 2a ed. Oxford University Press, 2005.

Semester II **IMB 204**

(Skill Development Course)

DIAGNOSTIC MICROBIOLOGY

Course Objective:

The aim of Medical Microbiology course is to introduce basic principles and application relevance of clinical disease for students who are in preparation for physicians. The content of rigorous course includes many etiological agents responsible for global infectious diseases.

Course Outcomes:

- To study the main characteristics of medically important microbes and to teach aseptic techniques, to provide understanding of microbial agents like Sterilization, Disinfection, antisepsis.
- To determine the activity of biocide, Germicide, Bacteriostatic, and asepsis by theoretical method, upon completion of this subject, the student will be able to evaluate information about careers.
- Learn about bacterial pathogenesis and diagnosis of urine, blood, CSF, sputum and swab andgenital swab.
- To learn about antimicrobial techniques and microbial resistance etc.
- Students gain practical experience in diagnosis of pathogens found in clinical specimens,
  Treatment of infectious diseases by antimicrobial agents.

Unit	Unit Title	Intended Learning Chapters		Hours of Instructions
		KL & AL1	**AL2, EL & SL**	
I	**Bacterial Pathogenesis**	Normal flora of the body, Pathogenesis of Bacterial infections,Bacterial virulence factors and their role in virulence and pathogenesis: a) Toxins :Exo and Endo Toxins b) Extracellular Enzymes		**12hrs**
II	**Diagnosis of Bacterial Infections**	Specimen collection, handling, processing, isolation &		**12hrs**

		Identification of infectious agents from clinical specimens: Urine, Blood, CSF, Sputum, Faeces, Wound/Pus swabs and Genital swabs.		
Unit III	**Medically important Bacteria-I**		Pathology, Laboratory Diagnosis, Epidemiology, Treatment and control of the following infectious agents. Gram Positive Cocci: *Staphylococci, Streptococci.* Gram Negative Cocci: *Neisseriae.* Gram Positive Bacill:*Corynebacterium, Bacillus, Clostridium, Mycobacterium*	**12hrs**
Unit IV	**Medically important Bacteria-II**		Pathology, Laboratory Diagnosis, Epidemiology, Treatment and control of the following infectious agents. a) Oxidase Negative Organisms:*Salmonella, Shigella, Escherichia and other bacteria of Enterobacteriaceae*. b) Oxidase Positive Organisms: *Pseudomonas, Vibrio, Yersinia, Campylobacter, Helicobacter.* Spirochaetes: *Treponemapallidum*	**12hrs**
Unit V	**Antimicrobials and Drug Resistance**		**Mechanisms of Antimicrobial agents: Antibacterial agents: Inhibitors of cell wall**	**12hrs**

			synthesisprotein synthesis and nucleic acid synthesis.Anti fungal, Antiviral, Anti parasitic agents,Antimicrobial sensitivity tests,Antimicrobial resistance.Biofilm andQuoram sensing	

References

1. Salle A.J. (2007) Fundamental principles of Bacteriology, 2^{n} ed. Tata Mc.Graw Hill Publications.
2. David Greenwood, Slack C.B. John Forrest Peutherer (2007), 7thed.Medical Microbiology, A guide to Microbial Infections, ELBS, Publications
3. Jawetz, Melnick, and Adelbaerg (2019) Medical Microbiology 28th Edition, International Mc.Graw Hill Publications
4. Ananthanarayana R. JayaramPanikar C.K. (2020), 11thed. A Text Book of Microbiology, Orient Longman.
5. Topley and Wilsons (2010) Microbiology and Micorbial Infections 10th Edition, Vol.8.The pathological society of Great Britain.
6. MoselloSchaechtler, GerroldMedoff, Barray. 1,Feigenseim (2012) Mechanisms of Microbial Diseases 7th edition, Wiliams and Wikins International
7. Bernard D.Davis. Renato Dulbecco, Herman N. Eisen, Harold S.Ginsberg (1996) Principles of Microbiology and immunology 4th Edition, Harper and Row publications.
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10. Greenwood D, Finch R.G, Davey P.G, Wilcox M.H, 2010. 9thed.bAntimicrobial chemotherapy, 5th edition, Oxford University Press, Oxford.
11. Finch R.G, Greenwood D, Norrby S.R. Whitley R.J. 2003. Antibiotic and chemotherapy, 8th edition. Churchill Livingstone, Edinburgh.

Semester II (Internal Elective) **IMB 204**

BIOINFORMATICS

Course Outcomes:

- Aimed to provide an overview of various bioinformatics tools, databases available and sequence analysis.
- Retrieve information from available databases and use them for microbial identifications.
- Provide knowledge on database concept, management, and retrieval along with utilization in gene and protein analysis. Protein Structure and prediction Molecular Modeling and docking.
- Gain ability to modify gene and protein structures in simulated systems.
- Develop competence to retrieve information from biological databases and integrate these biological information with computational software

Unit	**Unit Title**	**Intended Learning Chapters**		**Hours of Instructions**
		KL & AL1	**AL2, EL & SL**	
Unit- I	**Introduction to Biological Databases**	Types of databases, Nucleic Acid Sequence databases, Protein sequence databases .	Structure databases: Protein data bank (PDB), visualizing structural information (RasMol) Prediction analysis of DNA sequences (GRAIL; FGENES, Genescan) Sequence alignment (FASTA, BLAST,CLUSTALW) Phylogenetic analysis: Phylogenetic trees, Methods of analysis (Distance method, Neighbour joining method), Phylogenetic tree evaluation - PHYLIP, **MEGA**	**12hrs**
Unit II	**Protein Structure and Prediction**	Protein structure analysis, Secondary analysis, Motifs, profiles, patterns and fingerprints.	Sequence based protein prediction: Homology or comparative modeling: Remote homology (Threading), Protein function prediction.	**12hrs**
Unit III	**Molecular Modeling**	Molecular structures & Internal energy.	Areas of application-single molecule calculation, assemblies of	**12hrs**

			molecules. Introduction to molecular graphics & it's application.	
Unit IV	**Quantum Mechanics**	Electronic structure calculations, abinitio, semi-empirical and density fraction theory calculations.	Empirical force field models: Molecular mechanics, energy calculation, Bond stretch, angle bending, torsion angles, vanderwaal's interaction, etc), Molecular dynamics.	**12hrs**
Unit V	**Molecular docking & Statistics**	Introduction to molecular docking	Docking programs: Flexible & rigid body docking. Geometry bases, Energy bases, fragment based, descriptor method, grid method. Scoring docked complexes, Evaluation of docked prediction. Automated docking. Protein-ligand docking, Regression analysis, Fourier correlation transfer algorithm,RMS Deviation.	**12hrs**

References:

1. Beginners guide to bioinformatics for high throughput sequencing / Eric Lee, T W Tan. New
2. Jersey ; London : World Scientific, [2019]
3. Bioinformatics and phylogenetics : seminal contributions of Bernard Moret / Tandy Warnow,
4. editor. Cham, Switzerland : Springer, 2019
5. Essentials of bioinformatics. Volume I, Understanding bioinformatics: genes to proteins
6. / Noor Ahmad Shaik, Khalid Rehman Hakeem, BabajanBanaganapalli and RamuElango,
7. editors. Cham, Switzerland : Springer Nature, 2019

8. Bioinformatics: Principles & Applications by ZhumurGhosh, BibekanandMallick April 2008; Oxford University Press
9. Understanding Bioinformaticsby MarketZvelebil , Garland Science; 1 edition (April 30, 2007)
10. K. Attwood & D.J. Parry-Smith 1999. Introduction to Bioinformatics Pearson Education Asia

PRACTICAL1

MEDICAL MICROBIOLOGY

Community Engagement: Awareness on Bacterial & Fungal infections, misuse of Antibiotics and threats about antimicrobial resistance

1. Preparation of different types of culture media specific for pathogenic bacteria
2. Special staining techniques: AFB Staining, Albert Staining
3. Isolation, Culture, Identification of following bacteria:

Staphylococcus	*Streptococcus*
Salmonella	*Shigella*
E.coli	*Klebsiella*
Proteus	*Vibrio*
Pseudomonas	*Clostridium*
Mycobacterium tuberculosis	

4. Normal flora of the body
5. Bacteriological examination and culturing of the following clinical specimens. Urine, blood, faces, throat swabs, sputum, pus swab.
6. Antibiotic sensitivity test
7. Minimum inhibitory concentration.

PRACTICAL 2

Molecular biology & Any Internal elective Paper (core practical)

CELLULAR PROCESS (Core Practical)

1. Isolation of total nucleic acid from E.coli.
2. Determination of purity and quantity of DNA by UV absorption.
3. Isolation and analysis of plasmid DNA by gel electrophoresis.
4. Differentiation ssDNA and dsDNA.
5. Estimation of DNA by Diphenylamine method.
6. Isolation of RNA from yeast.
7. Estimation of RNA by orcinol Method.
8. Macromolecular composition of bacteria.
9. Isolation of protein by salt precipitation.
10. Galactosidose induction in E.coli strains.
11. Screening and isolation of streptomycin mutant resistant by gradient plate technique
12. Lethality curve construction
13. Induction of mutation in bacteria using UV light, photoreactivation, chemical mutagens and Ame`s test

14. Transfer of genes in bacteria by Transformation, Transduction and Conjugation
15. Curing of plasmids from E.coli strains

IMMUNO TECHNOLGY & MOLECUALR SIGNALLING (Internal elective)

1. AgglutatinationWidal (slide & tube) test for typhoid fever VDRL test for syphilis
2. Purification of IgG by Sephadex G column chromatography
3. Purification of antibodies by ammonium sulfate precipitation and dialysis
4. Dot ELISA
5. Sandwich ELISA
6. Antigen capture ELISA
7. Antibody capture ELISA
8. Rocket Immuno electrophoresis
9. ASO titre
10. Cell fractionation
11. Isolation of cell organelles
12. Squash preparation to study mitotic cell division
13. Squash preparation to study meiotic cell division
14. Biofilm formation and factors affecting it

ENZYME TECHNOLOGY (Internal elective)

1. Isolation of Amylase from saliva
2. Urease from horse gram.
3. Acid phosphatase from potatoes
4. Alkaline Phosphatase from serum
5. Cholinesterase from blood
6. Succinate dehydrogenase from liver
7. Invertase
8. Trypsin
9. Lactate dehydrogenase from serum
10. Purification and study of enzyme kinetics with respect to substrate and enzyme concentrations, pH, temperature, activators and inhibitors, and immobilization using some of the above enzymes.

BIOINFORMATICS (Internal elective)

1. Programming in C language (4-5 programmes)
2. Searching of databases (web searching)
3. MEDLINE searches for literature on a given topic, locating related materials on Medline
4. Web based biological sequence analysis protein coding regions
5. Hands on experience on various sequence analysis programs
6. Multiple sequence alignment programming

Unit	Unit Title	Intended Learning Chapters		Hours of Instructions
		KL & AL1	**AL2, EL & SL**	
Unit 1	**Quantitative tests**		Estimate the concentration of RNA and DNA	**12.5 hrs**
Unit I1	**Isolation techniques and Spectrophotometric techniques**	Determination of purity and quantity of DNA by UV absorption	Isolation of total nucleic acid from E.coli and Proteins	**12.5 hrs**
Unit 1II	**Genes transfer and mutation**		Transfer of genes in bacteria by Transformation, Transduction and Conjugation	**12.5 hrs**
Unit 1V **Immunotechnology (IE)**	Agglutatination & Purification tests	Test for typhoid fever VDRL test for syphili	Purification of IgG by Sephadex G column chromatography Purification of antibodies by ammonium sulfate precipitation and dialysis	**12.5 hrs**
Unit V (IE)	**Precipitation tests**	Dot ELISA Sandwich ELISA	Antigen capture ELISA Antibody capture ELISA Rocket Immuno electrophoresis	**12.5 hrs**
Unit VI (IE)	**Isolation, cell fractionation and cell division**	Cell fractionation Squash preparation to study mitotic and meiotic cell	Isolation of cell organelles	**12.5 hrs**

		division		
Unit 1V **Enzyme technology (IE)**	**Isolation**		Isolation of Amylase from saliva Urease from horse gram. Acid phosphatase from potatoes Alkaline Phosphatase from serum Cholinesterase from blood Succinate dehydrogenase from liver	**12.5 hrs**
Unit V **(IE)**	**Estimation**	Estimation of Different isolated enzymes from amylase, urease, acid phosphatase,alkaline phosphatase, cholihe esterase, invertase and succinate dehydrogenase		**12.5 hrs**
Unit VI **(IE)**	**Purification**		Purification and study of enzyme kinetics with respect to substrate and enzyme concentrations, pH, temperature, activators and inhibitors, and immobilization using some of the above enzymes	**12.5 hrs**
Unit IV **Bioinformatics (IE)**	**Programming**		Programmingin C language	**12.5 hrs**
Unit V	**Databases**	Searching of		**12.5 hrs**

(IE)		databases (web searching) MEDLINE searches for literature on a given topic, locating related materials on Medline		
Unit VI (IE)	**Sequence analysis**	Hands on experience on various sequence analysis programs	Web based biological sequence analysis protein coding regions Multiple sequence alignment programming	**12.5 hrs**

Course name	**course outcome**	**LO 1**	**LO 2**	**LO 3**	**LO 4**	**LO 5**	**LO 6**	**LO 7**	**LO 8**	**LO 9**	**LO 10**
Third Semester											
RECOMBINANT DNA TECHNOLOGY	To provide students with Conceptual knowledge on emergence of recombinant DNA technology from knowledge gained in biochemistry, genetics, cell biology and molecular biology. Gain knowledge on the significance of important enzymes and					✓					

	cloning. Able to Importance of different type of vectors available and basis for their construction and selection.										
	Overview of the important techniques used in sequencing, amplification and cloning of DNA					✓					
	Understand the major issues in heterlogous expression of gene and strategies employed to overcome Conceptual knowledge on ways to maximize the expression in prokaryotic and eukaryotic systems.					✓					
	Study the application of r DNA in various fields benefitting mankind.Gain practical experience in amplification and isolation of gene fragments and cloning.Use of *insilico* tools to design primers.					✓					

	Generation of restriction maps and identification of genes.										
FERMENTATION TECHNOLOGY	Outline the different fermentation techniques, bioreactor design, media formulation and strain improvement for industrial fermentations and explain the different stages in the downstream processing.							✓			
	Conceptual knowledge on production of Single cell protein, Wine and beer.							✓			
	Understanding of industrial production and purification of antibiotics, enzymes, amino acids,alcohol, acetone and butanol, discuss the spoilage and preservation of Foods and Dairy products.							✓			
	Explain the implication of Immobilized enzymes and cells in industrial production.										
	Hands on							✓			

	training on submerged and solid state fermentation and exploitation of bacteria, yeast and fungi in the industrial production of various products.										
BIOREMEDIATION Skill Development Course (Internal Elective)	Familiarize students with general principles and subject knowledge in the field of environmental Microbiology.								✓		
	The main purpose of this paper is to pay attention towards Extremophiles, Bioleaching, Aerobiology, Marine Microbiology, Sewage Microbiology and Bioremediation								✓		
	Describe role of microorganisms in varied fields of environmental microbiology like bioremediation and waste water treatment from leather, textile and food processing industries, various solid waste treatment technologies.								✓		

	Degradation of Xenobiotic compounds and the process to remove different heavy metals, other waste compounds which are harmful to human beings.								✓		
	Applications of bioremediation technology. Genetically Modified Microorganisms								✓		
ANIMAL PHARMACEUTICAL BIOTECHNOLOGY **Skill Development Course** **(Internal Elective)**	Providing students with a theoretical and practical understanding of animal biotechnology	✓				✓					
	Describe the structure of animal genes and genomes.					✓					
	Describe how genes are expressed and what regulatory mechanisms contribute to control of gene expression.					✓					
	Describe basic principles and techniques in genetic manipulation and genetic					✓					

	engineering; describe gene transfer technologies for animals and animal cell lines.										
	Describe techniques and problems both technical and ethical in animal cloning.							✓			
MOLECULAR AND IMMUNO DIAGNOSTICS Skill Developmen Course (Internal Elective	To explain the available molecular, genomic, proteomic and metabolomics diagnostic procedures available for various diseases					✓			✓		
	To interpret certain molecular reasons behind the certain hereditary diseases					✓			✓		
	To learn the technologies available and lacuna for the non-cultured and slow growing pathogens					✓			✓		
	To explain the available molecular, genomic, proteomic and metabolomics diagnostic procedures available for various diseases					✓			✓		
	To learn the technologies available and	✓	✓				✓				

	lacuna for the non-cultured and slow growing pathogens.										
RESEARCH METHODOLOY (Core Course)	Identify and discuss the role and importance of research in the social sciences.							✓			
	Identify and discuss the complex issues inherent in selecting a research problem, selecting an appropriate research design, and implementing a research project. sampling, data collection, analysis and reporting							✓			
	Identify and discuss the concepts and procedures of							✓			
PUBLIC HEALTH COMMUNICATION (External Elective)	Students identify the socio-economic, behavioural, biological, environmental, and other factors that impact human health and contribute to health disparities.		✓								
	Students understand the types of diseases and infections for promoting and protecting				✓						

	health across the life course.										
	Students get deeper understanding on communicable and non-communicable diseases.				✓						
	Students will develop health communication strategies to address public health issues				✓						
	Students will be able to develop health messages using mass media tools to a variety of audiences and will be able to translate scientific information for the benefit of different audiences.										

Semester III (Core Course) **IMB 301**

RECOMBINANT DNA TECHNOLOGY

Course Objective:

Recombinant DNA technology comprises altering genetic material outside an organism to obtain enhanced and desired characteristics in living organisms or as their products. This technology involves the insertion of DNA fragments from a variety of sources, having a desirable gene sequence via appropriate vector. The three important applications are: (1) Applications in Crop Improvement (2) Applications in Medicines and (3) Industrial Applications.

Learning Outcomes:

- To provide students with Conceptual knowledge on emergence of recombinant DNA technology from knowledge gained in biochemistry, genetics, cell biology and molecular biology.

- Overview of the important techniques used in sequencing, amplification and cloning of DNA
- Gain knowledge on the significance of important enzymes and cloning.Able to Importance of different type of vectors available and basis for their construction and selection.
- Understand the major issues in heterlogous expression of gene and strategies employed to overcome Conceptual knowledge on ways to maximize the expression in prokaryotic and eukaryotic systems.
- Study the application of r DNA in various fields benefitting mankind.Gain practical experience in amplification and isolation of gene fragments and cloning.Use of *insilico* tools to design primers. Generation of restriction maps and identification of genes.

Unit	**Unit Title**	**Intended Learning Chapters**		**Hours of Instructions**
		KL & AL1	**AL2, EL & SL**	
Unit- I	**Tools in r-DNA Technology**	Nucleic acid sequencing – Maxam Gilbert, Dideoxymethods, Automated DNA sequencing, Chemical Synthesis of DNA by phosphoramidite method.	Labeling of DNA: Nick translation, Random priming, Radioactive and non-radioactive nucleic acid probes, Amplification of DNA by PCR and its variants. DNA fingerprinting techniques – Southern blotting, RFLP, RAPD, AFLP.	**12hrs**
Unit II	**Cloning vehicles Enzymes**	Plasmids,bacteriophage cosmid, phagemids, shuttle and viral vectors T1 plasmids, vectors, bacterial yeast artificial chromosomes. DNA polymerases, S1 nuclease, BAL 31 nuclease, polynucleotide kinase, ligases, topoisomerases, phosphatases, methylase, reverse	Enzymes used in molecular cloning – Restriction and modification enzymes	**12hrs**

		transcriptase.		
Unit III	**Cloning in bacteria**	Introduction of cloned genes into host, Screening and detection of recombinant clones – genetic and immunochemical methods.	Core techniques of gene manipulation, Construction of c-DNA and genomic libraries. Generation of DNA fragments. Isolation and purification of RNA ,DNA (genomic and plasmid),	**12hrs**
Unit IV	**Expression in prokaryotes**	Expression of cloned genes in prokaryotes, Gene expression, factors influencing gene expression of cloned genes. Expression vectors (pET-based vectors pBAD vector), Protein purification, His-tag , GST-tag , Inclusion bodies ,	Problems associated with heterologous gene expression.Design of vectors for the over expression of recombinant proteins: selection of suitable promoter sequences, fusion protein tags, protease cleavage sites and enzymes, inducible expression systems; Methods to reduce formation of inclusion bodies.	**12hrs**
Unit V	**Expression in Eukaryotes**	Principles in maximizing gene expression, Baculovirus and pichia vectors system, Gateway cloning system.	Methods for analysis of gene expression at RNA and protein level using reporter genes such as (Chloramphenicol Acetyl Transferase) (*CAT*), ,Luciferase, β- galactosidese GUS,GPF etc.) . Antisense technology -Gene silencing techniques. Application of recombinant DNA technology in Biology, Agriculture and Medicine.	**12hrs**

Reference:

1. R.W. Old S.B. Primrose, Principles of Gene manipulation: An introduction to Genetic Engineering, 6th Edition, Blackwell Scientific, 2000
2. S.B. Primrose Principles Of Gene Manipulation And Genomics 7th Edition 2014.
3. James D. Watson_, A. Baker Tania, et alMolecular Biology of the Gene2017
4. P.Karanfilska, Dijana&P, Zoran&Stankovic, Bratislav. Recombinant DNA Technology and Genetic Engineering. 2015.
5. E.L. Winnacker, from Genes to Clones Introduction of gene technology VCH Publishers, 1998
6. A.N.Glazer, H.Nikaldo, Microbial Biotechnology. W.H. freeman, 2008
7. J.M. Walker, E.B.Gingold, Molecular Biology and Biotechnology, Panima Publishers, 2000
8. B.R.Glick and J.J. Pasternak, Molecular Biotechnology, Principles and applications of recombinant DNA, Panima Publishers 2015
9. S.B. Primrose, Molecular Biotechnology, 2019.
10. T.A. Brown,Gene Cloning and DNA Analysis: An Introduction2020

Semester III (Skill Development Course) **IMB 302**

BIOPROCESS TECHNOLOGY

Course Objective:

The course **provides the student with the basics of bioreactor technology**. It specifically focuses on bioreactor performance and operation and on the kinetics related to microbial growth, product formation, function of enzymes and transfer phenomena.

Learning Outcomes:

- Introduces various aspects of applied and Industrial Microbiology. The course helps the students to learn every important upstream and downstream components of fermentation process including strain selection, development, media design, formulation and recovery of products.

- Additionally, the course can educate the students about fermenter design, different types of fermentations and also the current trend of fermentation process in biotech-industry.

- Overall, the course helps in the student's exposure on industrial applications of bioprocesses.

- Aim of the course is the knowledge of the fermentative processes used in the industrial production of primary and secondary metabolites, biomasses and recombinant proteins.

- Students will learn to work with small bench fomenters. Batch fermentations will be carried out, monitoring and controlling several parameters in order to optimize the production of primary metabolites and recombinant proteins

Unit	Unit Title	Intended Learning Chapters		Hours of Instructions
		KL & AL1	**AL2, EL & SL**	
Unit- I	**Introduction to Bioprocessing**	Fermentation media composition Strategies for strain improvement of industrially important microbes. Development of microbial strains of economic importance	Design of fermentor-Aeration .agitation.foam control and sterlization Types of bioreactors-Submerged, airlift, fluidized bed. Fermentation types-Surface, submerged, solid state, batch, fed batch, continuous	**12hrs**
Unit II	**Industrial production of enzymes and organic solvents**	Enzymes of commercial applications	Enzymes of commercial applications; Production of Amylases; Glucose Isomerase; L Asparaginase, Proteases Renin; Penicillin acylases; Lactases; Pectinases; Lipases; Immobilization of enzymes & cells – methods, applications	**12hrs**
Unit III	**Industrial production of enzymes and organic solvents**		Organic acids: Production of Citric acid; Acetic acid; Lactic acid; Gluconic acid; Kojic acid; itaconic acid. Amino acids: Use of amino acids inindustry; methods	**12hrs**

			of production; Production of individual aminoacids (L-Glutamic acid; Lysine; L-Tryptophan).	
Unit IV	**Industrial production of vitamins and antibiotics**	Vitamins- Vitamin B12; Riboflavin; B carotene	Antibiotics: βeta-Lactam antibiotics (Pencillins); aminoglycoide (Streptomycin) Peptide antibiotic (vancomycin); Carbohydrate antibiotics (Tetracycline and antracyclines); Nucleoside antibiotics (5 – flurouracil); Aromatic antibiotics; Quinones)	**12hrs**
Unit V	**Industrial production of fermented beverages and food products**	Fermented beverages-P roduction of different types of wine and beer; Fermented foods-Health aspects of fermented foods,	Characteristics, processing , starter cultures used in production of Saurekraut, Miso, Natto, Buttermilk; Yogurt; Kefir, Kumiss, Cheeses Single cell protein-Microrganisms, substrates, conditions nutrition and uses of SCP.	**12hrs**

References:

1. Food Microbiology (5thed.) 2017. by W.C. Frazier & D.C. Tata McGraw Hill publishing house, New Delhi.
2. Foundation of Food Preservation by PeckhamGladays C 2007. 7th ed. Orient Long man Publishers.
3. Adams, M.R. Food Microbiology fundamentals & Frontiers 2018 American .Society foe Microbiology.5th ed. Washington. D.C.

4. M.G.Doyle and R.L. Buckmann .2012. A modern introduction to Food Microbiology,ASM Press
5. Casida L. e. Jr. 2016. Industrial Microbiology. John Wiley & Sons Inc., New Delhi
6. Gerald Reed (ed) 2004. Prescott & Dunn`s Industrial Microbiology
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8. V.K. Joshni, Ashok Panday 2013. Biotechnology: Food fermentation Vol I & II. IK International Publishing house Ltd.
9. F.M.Foster.2020. Food Microbiology.1st ed.CBS Publishers, New Delhi.
10. Crueger. 2019.A textbook of Industrial Microbiology. 3rd ed.New Age International Pvt. Ltd. New Delhi.

Semester III Skill Development Course (Internal Elective) **IMB 303**

BIOREMEDIATION

Course Objective:

The goal in bioremediation is to stimulate microorganisms with nutrients and other chemicals that will enable them to destroy the contaminants. The goal in bioremediation is to stimulate microorganisms with nutrients and other chemicals that will enable them to destroy the contaminants.

Learning Outcomes:

- Familiarize students with general principles and subject knowledge in the field of environmental Microbiology.

- The main purpose of this paper is to pay attention towards Extremophiles, Bioleaching, Aerobiology, Marine Microbiology, Sewage Microbiology and Bioremediation.

- Describe role of microorganisms in varied fields of environmental microbiology like bioremediation and waste water treatment from leather, textile and food processing Industries, various solid waste treatment technologies.

- Degradation of Xenobiotic compounds and the process to remove different heavy metals, other waste compounds which are harmful to human beings.

- Applications of bioremediation technology. Genetically Modified Microorganisms fate in environment and associated hazards.

Unit	Unit Title	Intended Learning Chapters		Hours of Instructions
		KL & AL1	**AL2, EL & SL**	
Unit- I	**Aerobiology and Sewage Microbiology**	Microbiology of the air: Microbes and microbial propagules in air, methods	. Significance of aerobiological studies, Nature and	**12hrs**

		for microbial analysis of air, standard limits, Sewage Microbiology: Composition and source of sewage, Microbial diversity, primary, secondary, tertiary and quaternary treatments.	diseases caused by aeroallergens and their control.	
Unit II	**Solid waste treatment**	Saccharification, Gasification, Composting, Bio Gas Generation. Effective Waste Water Treatment and its Mangement By microorganisms in leather , textile and food processing industries.	(Use of commercial blends of microorganisms of immobilized cells/enzymes.) Application of Enzymes in bioremediation of solid wastes and soils. Biosensor technology.	**12hrs**
Unit III	**Microbial leaching and Extremophiles :**	leaching of ores- Microorganisms involved in Bioleaching, Chemistry of Bioleaching, Factors affecting bioleaching, Types of leaching with special reference to copper, Uranium and Gold.	Microbial Extremophiles: Acidophilic, Alkalophilic, Thermophilic, Barophilic, Osmophilic ,Halophilic Microbes, Obligate Anaerobes – Mechanisms and Adoption .Application of Thermophiles and Extremophiles	**12hrs**
Unit IV	**Bioremediation**	Ex-situ and in-situ processes; Intrinsic and engineered bioremediation. Microorganisms for environmental cleanup of contaminated- Hazardous Waste sites and heavy metal polluted sites.	Degradation of Xenobiotics – Oil Slicks, Detergents, Plastics, Recalcitrance of Pesticides in Soil (eg.DDT). Biopolymers and super bug. Applications of bioremediation technology: Replacement of petrochemicals, reversal of Global	**12hrs**

			warming. Fate of engineered microorganisms in the environment. Phytoremediation in Environment Management: Phytodegradation,Rhizodegradation, Phytovolatalization Volatilization of toxic metals by microorganisms.	
Unit V	**Marine Microbiology and anti-fouling strategies:**	Marine Microbiology: Microbial biofilms, Marine polysaccharides	biomedical and biotechnological applications. Biofouling and corrosion: Biofouling organisms, problems due to biofouling, antifouling paints and its environmental pollution, biotechnological approach to biofouling control, aerobic and anaerobic induced corrosion.	**12hrs**

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3. Soil Microenvironment for Bioremediation and Polymer Production Hardcover by NaziaJamil (Editor), Prasun Kumar (Editor), RidaBatool (Editor), Publisher : Wiley-Scrivener; 1st edition (9 January 2020).
4. Bioremediation of Pollutants : From Genetic Engineering to Genome Engineering Edited by Vimal Chandra Pandey , Edited by Vijai Singh Publisher Elsevier Science Publishing Co Inc- 2020
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Semester III Skill Development Course (Internal Elective) IMB 303

ANIMAL PHARMACEUTICAL BIOTECHNOLOGY

Course objective:

Animal biotechnology is the use of science and engineering to modify living organisms. The goal is to make products, to improve animals and to develop microorganisms for specific agricultural uses. Pharmaceutical biotechnology is a relatively new and growing field in which the principles of biotechnology are applied to the development of drugs. A majority of therapeutic drugs in the current market are bioformulations, such as antibodies, nucleic acid products and vaccines.

Learning Outcomes:

- Providing students with a theoretical and practical understanding of animal biotechnology.
- Describe the structure of animal genes and genomes.
- Describe how genes are expressed and what regulatory mechanisms contribute to control of gene expression.
- Describe basic principles and techniques in genetic manipulation and genetic engineering, describe gene transfer technologies for animals and animal cell lines.
- Describe techniques and problems both technical and ethical in animal cloning.

Unit	Unit Title	Intended Learning Chapters		Hours of Instructions
		KL & AL1	**AL2, EL & SL**	
Unit- I	**Animal cell culture media and sterilization**	Media for culturing cells and tissues; natural and defined media Preparation of various tissue culture media, sterilization and storage Sterilization of various equipments and apparatus Short-term	Development and maintenance of cell lines	**12hrs**

		lymphocyte culture (suspension cultures)		
Unit II	**Techniques in animal cell culturing and breeding**	Techniques in Animal Tissue Culture Development and maintenance of cell lines	*Invitro* culture of oocytes/embryos Cell/embryo cryopreservation Conventional methods of animal improvement, predominantly selective breeding and cross breeding	**12hrs**
Unit III	**Biotechnology for animal improvement**	Embryo biotechniques for augmentation of reproductive efficiency and faster multiplication of superior germ plasm	Transgenesis for animal improvement and production of animals as bioreactors for proteins of pharmaceuticals value Gene mapping in farm animals Marker-assisted selection and genetic improvement of livestock	**12hrs**
Unit IV	**Drug discovery and delivery systems**	Drug Discovery and the drug development process	The impact of genomics, proteomics and related technologies upon drug discovery. Delivery of Biopharmaceuticals-Oral delivery systems – Pulmonary delivery – Nasal, tranmucosal and transdermal delivery systems.	**12hrs**
Unit V	**Biopharmaceuticals**	The cytokines – The interferon family, cytokines as Biopharmaceuticals. TNF – therapeutic aspects.	Haemopoietic growth factors, Growth factors, Hormones of therapeutic interest, Blood products,	**12hrs**

			therapeutic enzymes and Nucleic acid therapeutics.	

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Semester III Skill Development Course (Internal Elective) **IMB 303**

MOLECULAR AND IMMUNO DIAGNOSTICS

Course Objective

Molecular diagnostics is a collection of techniques used to analyze biological markers in the genome and proteome, and how their cells express their genes as proteins, applying molecular biology to medical testing. In medicine the technique is used to diagnose and monitor disease, detect risk, and decide which therapies will work best for individual patients and in agricultural biosecurity similarly to monitor crop- and livestock disease, estimate risk, and decide what quarantine measures must be taken.

Learning Outcomes:

- To explain the available molecular, genomic, proteomic and metabolomics diagnostic procedures available for various diseases
- To interpret certain molecular reasons behind the certain hereditary diseases
- To learn the technologies available and lacuna for the non-cultured and slow growing pathogens.
- To explain the available molecular, genomic, proteomic and metabolomics diagnostic procedures available for various diseases
- To learn the technologies available and lacuna for the non-cultured and slow growing pathogens.

Unit	**Unit Title**	**Intended Learning Chapters**		**Hours of Instructions**
		KL & AL1	**AL2, EL & SL**	
Unit- I	**Animal cell culture media and sterilization**	Media for culturing cells and tissues; natural and defined media Sterilization of various equipments and apparatus Short-term lymphocyte culture (suspension cultures) Development and maintenance of cell lines	Preparation of various tissue culture media, sterilization and storage	**12 hrs**
Unit II	**Techniques in animal cell culturing and breeding**	Conventional methods of animal improvement, predominantly selective breeding and cross breeding	Techniques in Animal Tissue Culture Development and maintenance of cell lines *Invitro* culture of oocytes/embryos Cell/embryo cryopreservation	**12 hrs**
Unit III	**Biotechnology for animal improvement**	Embryo biotechniques for augmentation of reproductive efficiency and faster	Transgenesis for animal improvement and production of animals as bioreactors for	**12 hrs**

		multiplication of superior germ plasm	proteins of pharmaceuticals value Gene mapping in farm animals Marker-assisted selection and genetic improvement of livestock	
Unit IV	**Drug discovery and delivery systems**	Drug Discovery and the drug development process.	the impact of genomics, proteomics and related technologies upon drug discovery. Delivery of Biopharmaceuticals- Oral delivery systems – Pulmonary delivery – Nasal, tranmucosal and transdermal delivery systems.	**12hrs**
Unit V	**Biopharmaceuticals**	The cytokines – The interferon family, cytokines as Biopharmaceuticals. TNF – therapeutic aspects.	Haemopoietic growth factors, Growth factors, Hormones of therapeutic interest, Blood products, therapeutic enzymes and Nucleic acid therapeutics.	**12hrs**

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Semester III (Core Course) **IMB 304**

RESEARCH METHODOLOGY

Course Objective:
Research methodologies tell the systematic method for acquiring data and studying it for deriving out crucial findings. This is an important process that helps in solving problems and making business decisions. It enables management for properly organizing their efforts in a right direction for generating an idea.

Learning Outcomes:

- Identify and discuss the role and importance of research in the social sciences.
- Identify and discuss the issues and concepts salient to the research process.
- Identify and discuss the complex issues inherent in selecting a research problem, selecting an appropriate research design, and implementing a research project.
- Identify and discuss the concepts and procedures of sampling, data collection, analysis and reporting.

Unit	**Unit Title**	**Intended Learning Chapters**		**Hours of Instructions**
		KL & AL1	**AL2, EL & SL**	
Unit- I	**Research Significance & Planning**	Types: Fundamental, Applied- Qualities of Research- Steps involved in Scientific Research. Need for literature review- sources of literature- Hypothesis formation – Types of Hypothesis.	Selection of a problem- Formulation of Research Problem	**12hrs**
Unit II	**Research Design & Report writing:**	Basic principles- Features of a good	Sampling methods:	**12hrs**

		design-experimental design. types of reports – layout of research report-principles of writing – references – appendices	characteristics of a good sample design, probability and non-probability sampling methods. Components- - format of publication in research journal-paper presentations: planning, preparation, visual aids-preparation of research proposal.	

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Semester III (External Elective)

PUBLIC HEALTH COMMUNICATION

Course Objective:

Public health experts recognize health communication as vital to public health programs that address disease prevention, health promotion, and quality of life. It can make important contributions to promote and improve the health of individuals, communities, and society.

Health communication strategies aim to change people's knowledge, attitudes, and/or behaviors; for example: Increase risk perception. Reinforce positive behaviors. Influence social norms.

Learning Outcomes:

- Students identify the socio-economic, behavioural, biological, environmental, and other factors that impact human health and contribute to health disparities.
- Students understand the types of diseases and infections for promoting and protecting health across the life course.
- Students get deeper understanding on communicable and non-communicable diseases.
- Students will develop health communication strategies to address public health issues.
- Students will be able to develop health messages using mass media tools to a variety of audiences and will be able to translate scientific information for the benefit of different audiences.

Unit	**Unit Title**	**Intended Learning Chapters**		**Hours of Instructions**
		KL & AL1	**AL2, EL & SL**	
Unit- I	**Public Health**	Public Health : Socio economic factors , education, occupation, ethnicity and health , Inequalities and Communication- opportunities and challenges- trans-disciplinary nature of mass communication and public health- Health delivery system in India and AP.	Disparities in Health- Globalization and health- Health	**12hrs**
Unit II	**Human Life**	Human life cycle -	Types of infections	**12hrs**

	Cycle and Infections	Sources & spread of infections- Viral diseases : Polio myelitis, Influenza virus, Hepatitis, Human Immunodeficiency Virus (HIV),Corona virus.	-Wound infections, Urinary tract infections, Respiratory tract infection, Blood and cerebrospinal fluid infections-	
Unit III	**Diseases and Infections**	Communicable and Non communicable diseases- Introduction to nutrition inter relationship between food, nutrients & health.	Government focus on Health issues affecting women and children(nutrition , breast , cervical cancer , breastfeeding etc,). -Nutritional status and susceptibility to infection- Health care evaluation	**12hrs**
Unit IV	**Health Communication**	Health Communication: Designing and developing communication strategies	-Social and behavior Change Commu-nication(SBCC), Nudge theory, huma cntered design. ,risk communicatio communication mode	**12hrs**
Unit V	**Reporting and Writing Health Reports**	Health Reporting: Writing health data to different audience through print, electronic and social media,	design of effective health communication interventions- Writing health reports.	**12hrs**

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PRACTICAL 5

Recombinant DNA Tehnnology (Core Practical)

RECOMBINANT DNA TECHNOLOGY

1. Isolation of Plasmid DNA mini and maxi, preps
2. Restriction digestion of plasmid, single and double digestion
3. Cloning of genes
4. Determination of molecular weight.
5. Construction of restriction map of a plasmid *insilico* using add gene and restriction mapper
6. Identification of coding region or ORF using ORF finder
7. Design of PCR primers
8. Amplification of DNA by PCR.
9. Purification of DNA fragment from gel by electro elution
10. Purification of DNA fragment from gel by affinity chromatography

Unit	**Unit Title**	**Intended Learning Chapters**		**Hours of Instructions**
		KL & AL1	**AL2, EL & SL**	
Unit- I	**Isolation**	Isolation of Plasmid DNA mini and maxi, preps	**Run the agarose gel electrophoresis**	**12.5 hrs**
Unit II	**Digestion and mapping**	Restriction digestion of plasmid, single and double digestion	Cloning of genes Determination of molecular weight. Construction of restriction map of a plasmid *insilico* using add gene and	**12.5 hrs**

			restriction mapper	
Unit III	**Purification**		Purification of DNA fragment from gel by electro elution and affinity chromatography	**12.5 hrs**

Practical 6
Bioprocess technology & Any Internal elective
BIOPROCESS TECHNOLOGY

1. Citric acid production by surface fermentation method and estimation of citric
2. acid
3. Wine production
4. Estimation of ethanol produced in fermented grape juice
5. Production of penicillin by submerged fermentation & estimation
6. Lactic acid fermentation by Lactobacillus and its estimation
7. Production of enzymes by microorganisms – Amylase, protease
8. Production of vitamins and estimation
9. Preparation of fermented foods – Sauerkraut by solid state fermenation
10. Production of fermented dairy products
11. Production of fermented cereal product

BIOREMEDIATION (Internal elective)

1. Isolation, identification and enumeration of microorganisms in the air and sewage.
2. Microbial antagonism in the environmental samples
3. Isolation of thermophilic organisms from compost
4. Isolation and cultivation of green sulfur bacteria from polluted waters
5. Impact of nitrogen sources on the heterocyst differentiation & frequency of heterocystous blue green algae
6. Metal tolerance in bacteria isolated from polluted & non polluted waters
7. Cultivation of anaerobes isolated from sediments or deeper layers of soil
8. Demonstration of corrosion of metals by anaerobic sulfate reducing bacteria(SRB)
9. Bioremediation and degradation of pesticides
10. Sewage treatment plant – Visit

ANIMAL PHARMACEUTICAL BIOTECHNOLOGY (Internal elective)

1. Preparation of various animal tissue culture media
2. Animal cell, fusion technique
3. Preparation of primary and secondary animal cell culture
4. Assessment of cell viability in lymphoid organs
5. Effect of warm and cold trypsinization on cell disaggregration
6. Screening for new microbial agents in terrestrial and marine environment
7. Evaluation of efficacy of different routes of drugs
7. Pharmacokinetic studies (ADME properties) of some drugs
8. Estimation of therapeutic enzyme activity in microbial sources

MOLECULAR AND IMMUNO DIAGNOSTICS (Internal elective)

1. Preparation of adjuvants
2. Immunodiffusion, Radial immuno diffusion
3. Raising of antibodies
4. IgG purification by ammonium sulphate precipitation method
5. Flourescent antibody technique
6. Dot ELISA
7. Sandwich ELISA
8. Antigen Capture ELISA
9. Antibody Capture ELISA
10. Rocket Immuno Electrophoresis
11. ASO titre

Unit	**Unit Title**	**Intended Learning Chapters**		**Hours of Instructions**
		KL & AL1	**AL2, EL & SL**	
Unit- I	**Organic acids & Antibiotics**	Citric acid production by surface fermentation method and estimation citric acid Wine production	Estimation of ethanol produced in fermented grape juice Production of penicillin by submerged fermentation & estimation Lactic acid fermentation by Lactobacillus and its estimation	**12.5 hrs**
Unit II	**Enzymes & Vitamins**	Production of enzymes by microorganisms – Amylase, protease Production of vitamins	Estimation of Vitamins and enzymes	**12.5 hrs**
Unit III	**Fermented foods**	Preparation of fermented foods – Sauerkraut	Lactic acid fermentation Fermentation process during curdling, estimation of lactose, lactic acid, protein,	**12.5 hrs**

			bacterial count	
Unit IV (Bioremediation) (IE)	**Aerobiology and Sewage Microbiology**	Isolation, identification and enumeration of microorganisms in the air and sewage. Sewage treatment plant – Visit		**12.5 hrs**
Unit V	**Solid waste treatment**	Isolation, identification and enumeration of microorganisms in the air and sewage	Metal tolerance in bacteria isolated from polluted & non polluted waters Cultivation of anaerobes isolated from sediments or deeper layers of soil. Isolation of thermophilic organisms from compost Isolation and cultivation of green sulfur bacteria from polluted waters	**12.5 hrs**
Unit VI	**Bioremediation**	Bioremediation and degradation of pesticides		**12.5 hrs**
Unit IV Animal pharmaceutical biotechnology (IE)	**Techniques in animal cell culturing**	Preparation of various animal tissue culture media Preparation of primary and secondary animal cell culture		**12.5 hrs**
Unit V	**Biotechnology & Drug discovery**	Assessment of cell viability in lymphoid organs Effect of warm and cold trypsinization on cell disaggregration	Screening for new microbial agents in terrestrial and marine environment 7. Evaluation of efficacy of different routes of drugs	**12.5 hrs**

Unit VI	**Pharmacokinetic studies**		Pharmacokinetic studies (ADME properties) of some drugs	**12.5 hrs**
Unit IV Molecular and immuno diagnostics (IE)	**Immunodiffusion**	Preparation of adjuvants	Immunodiffusion, Radial immuno diffusion	**12.5 hrs**
Unit V	**Precipitation test**		Dot ELISA Sandwich ELISA Antigen Capture ELISA Antibody Capture ELISA	**12.5 hrs**
Unit VI	**Purification**	Raising of antibodies Flourescent antibody technique	IgG purification by ammonium precipitation method	**12.5 hrs**

Course name	**course outcome**	**LO 1**	**LO 2**	**LO 3**	**LO 4**	**LO 5**	**LO 6**	**LO 7**	**LO 8**	**LO 9**	**LO 10**
Fourth Semester											
OMIC TOOLS FOR MICROBIAL BIOPROSPECTING	Understanding the basic concepts of genomics, metagenomics, proteomics, learning of genomics tool box with special focus on PCR and Non PCR based approaches					✓					
	Understanding of DNA microarrays, Protein arrays, Community genome arrays Phylogenetic oligonucleotide					✓					

	arrays, depth of knowledge on application of Omic technologies in Bioprospecting and Agriculture.										
	Explain the principles and protocols of 2DE, Mass spectrometry analysis MS 2-DE/MS, ICAT					✓					
	Conceptual knowledge on Yeast two hybrid analysis; Peptide finger printing, protein chip assay										
	Training on bioinformatics tools like nBLAST, pBLAST, Multiple Sequence Analysis and Gene Annotation of genome sequences Amplification of 16S DNA, Separation and characterization of proteins.					✓					
BIOENGINEERING	Examine the application of biological and engineering principles to problems involving microbial, mammalian, and biological/biochemicalsystems.Recognize the fundamentals of fermentation									✓	

	technology.										
	Comprehend growth and metabolism, genetics and metabolic engineering in the age of genomics, the biological basis for monitoring bioprocesses including process analytical technology, and applications of the modern biological concepts in bioprocess developments									✓	
	Assess power requirements in bioreactors, modeling of bioprocesses, traditional and new concepts in bioprocess monitoring, and the biological basis for industrial fermentations and cell cultures.									✓	
	Distinguish bioreactor operations in bacteria and mammalian cell systems, oxygen transfer and shear in bioreactors, process improvement through metabolic manipulations,									✓	

	and scale-up of bioreactors such as bacterial, yeast, and mammalian cells.										
	Analyze the bioprocess paradigm: Scale-down, bioprocess simulation and economics, sterilization, and bioburden in biological manufacturing.									✓	
TECHNO ENTRENEURSHI BIOETHICS	Understand their personal characteristics and interests to that of the "successful" entrepreneur.							✓			✓
	Identification and assess sources of support for small businesses and entrepreneurs							✓			✓
	Evaluate methods of entering an entrepreneurship venture – including but not limited to starting a new venture, buying an existing business, or becoming a franchisee										✓
	Acquire idea and information on funding for start-ups							✓			✓
	Different forms of patents, terms and conditions of							✓			

	patents										

Semester IV (Skill Enhancement Course) **IMB 401**

OMIC TOOLS FOR MICROBIAL BIOPROSPECTING

Course Objective:

Core technologies in systems toxicology are the "omics" techniques, namely genomics, transcriptomics, proteomics and metabolomics. Omics technologies have also been used for in vitro and in vivo testing of NPs. One advantage might be the identification of new targets and markers

Learning Outcomes:

- Understanding the basic concepts of genomics, metagenomics, proteomics, learning of genomics tool box with special focus on PCR and Non PCR based approaches
- Understanding of DNA microarrays ,Protein arrays, Community genome arrays Phylogenetic oligonucleotide arrays, depth of knowledge on application of Omic technologies in Bioprospecting and Agriculture.
- Explain the principles and protocols of 2DE, Mass spectrometry analysis MS 2-DE/MS, ICAT
- Conceptual knowledge on Yeast two hybrid analysis; Peptide finger printing, protein chip assay
- Training on bioinformatics tools like nBLAST, pBLAST, Multiple Sequence Analysis and Gene Annotation of genome sequences Amplification of 16S DNA, Separation and characterization of proteins.

Unit	**Unit Title**	**Intended Learning Chapters**		**Hours of Instructions**
		KL & AL1	**AL2, EL & SL**	
Unit- I	**Introduction to omics**	Genomics, Transcriptomics, proteomics, metabolomics and omic data bases. Sequencing by conventional, automated and	PCR dependent approaches of DNA amplification RFLP, AFLP, T-RFLP, ARDRA,, RISA, DGGE/TGGE, Real-time PCR (q-	**12hrs**

		next generation sequencing approaches- advantages and limitations.	PCR). PCR-independent amplification approaches- Multiple Displacement Amplification (MDA)	
Unit II	**Microbiome-Metagnomic tools (sequence based and Functional metagenomics**).	Whole genome analysis. Functional genomics and Metagenomic shift. Pipeline of the metagenomic project. Culturomics.	Advantages and limitation of Metagenomics approach. Accessing microbial diversity using culture independent methods.	**12hrs**
Unit III	**Proteomic Tools**	Proteome, Functional proteomics, metaproteome. Identification of post-translational modifications:	Proteome tools – 2-DE Mass spectrometry analysis MS (ESI-MS/MS) 2-DE/MS, ICAT, Yeast two hybrid analysis; Peptide finger printing. Identification of post-translational modifications: Phosphorylation, Glycosylation, Acetylation	**12hrs**
Unit IV	**Proteome analysis**	Methods for sequencing proteins: Edman degradation. Sequence based protein prediction:	Homology or comparative modeling, Remote homology (Threading), Protein function prediction.	**12hrs**
Unit V	**Microarrays**	DNA and Protein arrays, Analysis of gene expression patterns using labeled probes.	Functional gene arrays (FGA), Community genome arrays (CGA) Phylogenetic oligonucleotide arrays-Application and limitations.	**12hrs**

			Application of omic technologies in Bioprospecting. Integration of omic platforms, interactomics, Systems biology	

References:

1. Principles of Proteomics by Richard Twyman, Bios Scientific Publishers Tylor and Francis group 2004.
2. Proteomics. S.R. Pennigton and M.J. Dunn Viva books. New Delhi, 2002.
3. Genomes 3 by T.A. Brown, Garland science Tylor and Francis group 2006.
4. Introduction to Genomics by Lesk 2015.
5. Introduction to protein Science: Architecture, Function and Genomics by Lesk 2010 Oxford.
6. Genomics - Fundamentals and Applications by SupratimChoudhuri& David B Carlson 2008.
7. Molecular Cell Biology, Harvey Lodish, Arnold Berk, S Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James Darnell 4th edition W.H. Freeman and Company 2000.
8. Genomics and Proteomics Principles, Technologies and Applications by DevarajanThangadurai and JeyabalanSangeetha1 ed. CRC and Apple Academic Press 2015Microarrays for an integrative genomics. A.J. Kohane, IS., Kho, A and Butte Barnes and Nobles, MIT press.
9. Molecular biology Philip C Turner Garland Science2005.
10. Discovering Genomics, Proteomics & Bioinformatics by A. Malcolm Campbell and Laurie J. Heyer 2ed. Benjamin Cumming 2008.
11. Proteomics: Targeted Technology, Innovations and Applications. Manuel Fuentes and Joshua LaBaer, Caister Academic Press 2014.
12. Evolutionary Genomics and Proteomics by Mark Pagel and Andrew Pomiankowski1st edition Sinauer Associates Inc; 2008.
13. Applying Genomic and Proteomic - Microarray Technology in Drug Discovery Robert S. Matson 2 ed. CRC Press 2003.
14. Methods in Microarray Normalization by Philip Stanfford CRC Press 2008.

Semester IV (Core Course) **IMB 402**

BIOENGINEERING

Course Objective:

Bioengineers work with doctors, therapists and researchers to develop systems, equipment and devices in order to solve clinical problems. Biomedical engineers have developed a number of life-enhancing and life-saving technologies. These include: Prosthetics, such as dentures and artificial limb replacements

Learning Outcomes:

- Examine the application of biological and engineering principles to problems involving microbial, mammalian, and biological/biochemical systems.Recognize the fundamentals of fermentation technology.
- Comprehend growth and metabolism, genetics and metabolic engineering in the age of genomics, the biological basis for monitoring bioprocesses including process analytical technology, and applications of the modern biological concepts in bioprocess developments.
- Assess power requirements in bioreactors, modeling of bioprocesses, traditional and new concepts in bioprocess monitoring, and the biological basis for industrial fermentations and cell cultures.
- Distinguish bioreactor operations in bacteria and mammalian cell systems, oxygen transfer and shear in bioreactors, process improvement through metabolic manipulations, and scale-up of bioreactors such as bacterial, yeast, and mammalian cells.
- Analyze the bioprocess paradigm: Scale-down, bioprocess simulation and economics, sterilization, and bioburden in biological manufacturing.

Unit	**Unit Title**	**Intended Learning Chapters**		**Hours of Instructions**
		KL & AL1	**AL2, EL & SL**	
Unit I	**Introduction to Bioprocess Engineering**	Microbial growth parameters and its kinetics, Role and importance of downstream processing in biotechnological processes. An overview of bioseparation; Problems and requirements of	Downstream process economics. Scale up and scale down of fermentation process	**12hrs**

		bioproduct purification		
Unit II	**Down Stream Processing**	Physico-chemical basis of bio-separation processes. Removal of particulate matter; biomass; and insolubles: flocculation and sedimentation; centrifugation and filtration methods;	Cell disruption methods; Enrichment Operations: precipitation methods (with salts; organic solvents; and polymers; extractive separations; aqueous two-phase extraction; supercritical	**12hrs**
Unit III	**Membrane and Chromatography based Separation**	Membrane separations: Membrane based seperation theory; Types of membranes; Types ofmembrane processes (Dialysis; Ultrafiltration; microfiltration and Reverse Osmosis).	Chromatographic separations: Paper; TLC; Adsorption; Ion exchange; Gel filtration; affinitychromatographic separation processes; GC; HPLC; FPLC; Electrophoretic separation.	**12hrs**
Unit IV	**Product formulation**	Final product polishing and Case studies	Products polishing: Crystallization and drying; Production and purification of biopharmaceuticals of therapeutic value (therapeutic enzymes, blood products, hormones, monoclonal antibodies, vaccines)	**12hrs**
Unit V	**Regulatory Procedures**	Good laboratory practices, good manufacturinfg practices and FDA regulations.	Regulations for recombinant DNA research and manufacturing process. Regulations for clinical trials. Documentation and compliance, in India and other countries. Rules for import and export of biological materials	**12hrs**

References:

1. Adrian Stator, Nigel Scott and Mark fowler (2 nd edition): Plant Biotechnology – The Genetic Manipulation of Plants, Oxford University Press, 2003

2. H.S. Chawla: Biotechnology in Crop improvement, International Book Distributing Company,. 1998
3. P.K. Gupta: Biotechnology & Genomics, Rastogi Publishers co. Meerut, 2004
4. Plant Biotechnology by Ramawat ,2008
5. Encyclopedia of applied Plant Sciences –(2 nd edition): B.Thomas: D.J. Murphy & B.G. Muriay ,2016
6. Metabolic Engineering of Plant secondary Metabolism: R.Verpoorte& A.W. Alfermann; Kluwer Academic Publishers, 2000.
7. Plant Biochemistry & Molecular Biology, 2nd Ed., edited by P.J. Lea & R.C. Leegood, 1999; John Wiley & Sons Ltd.1999
8. J.Hammond, P.M.C. Garvey and V. Yusibov (Eds.): Plant Biotechnology, springer Verlag, 2000
9. T-J.Fu, G. Singh, and W.R.Curtis (Eds.):Plant Cell and Tissue Culture for the Production of Food Ingredients, Kluwer Academic/Plenum Press, 1999.
10. H.S.Chawla: 2nd Ed, Biotechnology in crop Improvement, International Book Distributing Company, 1998.
11. R.J. Henry: 1stEd,Practical Application of Plant Molecular Biology, Chapman and Hall, 1997
12. P.K. Gupta: Elements of Biotechnology, Rastogi and Co. Meerut.1996
13. **Panpatte**, Deepak G., **Jhala**, Yogeshvari K. (Eds.)Nanotechnology for Agriculture:
    a. Crop Production& Protection,2019.
14. **Panpatte**, Deepak G., **Jhala**, Yogeshvari K. (Eds.) Nanotechnology for Agriculture
15. Advances for Sustainable Agriculture,2019
16. Khalid RehmanHakeem,Tanveer Bilal Pirzadah,Nanobiotechnology in Agriculture:
17. An Approach Towards Sustainability (Nanotechnology in the Life Sciences) 2020
18. Keith Roberto,How-To Hydroponics, Fourth Edition 4th Edition,1994
19. Suman, B.C ,. Sharma ,V.P Mushroom cultivation in India,Daya Books,2007

Semester IV (Skill Enhancement Course) **IMB 403**

TECHNO ENTRENEURSHIP & BIOETHICS

Course Objective

The Technopreneurship course will provide you with an introduction to the technology venture creation and management through a mix of experiential learning, skill building and most importantly, mind-set shift. Demonstrating awareness of the ethical, legal, and social implications of issues related to bioethics. Examining existing frameworks and challenging normative assumptions and expectations. Communicating one's decision and moral action strategy to various stakeholders and parties.

Learning Outcomes:

- Understand their personal characteristics and interests to that of the “successful” entrepreneur,

- Identification and assess sources of support for small businesses and entrepreneurs.
- Eevaluate methods of entering an entrepreneurship venture – including but not limited to start a new venture, buying an existing business, or becoming a franchisee
- Acquire idea and information on funding for start-ups
- Different forms of patents, terms and conditions of patents

Unit	Unit Title	Intended Learning Chapters		Hours of Instructions
		KL & AL1	**AL2, EL & SL**	
Unit- I	**Biosafety and Bioethics**	Biosafety, Definition, RequirementBiosafety and biodiversity, Biosafety for human health and environment, Social and ethical issues, Biosafety in relation to transgenic research and applications.	Regulations for clinical trials, Documentation and Compliance, in India and selected countries - Rules for import and export of biological materials.	**12 hrs**
Unit II	**Regulatory Procedures**	Good laboratory practice, Good manufacturing practice and FDA regulations - Regulations for Animal ethical committee, Human ethical committee recombinant DNA research and manufacturing process.	Disposal of biomedical, chemical waste and animal waste.	**12 hrs**
Unit III	**Entrepreneurship Development**	Significance of Entrepreneurship in Economic Development; Characteristics, qualities and pre – requisites of entrepreneur. Emerging trends in Entrepreneurship: Technopreneurship, netpreneurs, agripreneurs, Women entrepreneurship, Portfolio entrepreneurship, Franchising.	Business opportunities identification-- Generation of Ideas; screening of Ideas and Selection; Identifying new Projects; Preparing Project Profiles, Feasibility Study of project. Steps involved in preparations for a New Venture Concept of SME's, Govt. support to	**12hrs**

			new enterprise; Source of Finance; Entrepreneurship Development Programmes (EDP);	
Unit IV	**Intellectual property**	Fundamentals regarding intellectual property (IP), intellectual property protection (IPP) and intellectual property rights (IPR). TRIPs (Trade Related Intellectual Property Rights) and GATS (General Agreement on Trade in Services).	OECD guidelines for chemical testing pertaining to use as drug, related substances, excipients, toxicity, etc.WHO guidelines for standardization of raw material and finished products including herbal products.	**12 hrs**
Unit V	**Patent and Copy Rights**	Indian Patent Act 1970 and the Product Patent Regime, 2005; Patent application-forms and guidelines, fee structure, time frames, jurisdiction aspects;	Filing of a patent application; specialized services-search requests, costs; Types of patent applications-provisional, non provisional, PCT and convention patent applications; Patent infringement.Copy rights - Publication-article / thesis	**12 hrs**

References:

1. Sree Krishna V 2007. Bioethics and Bio safety in Biotechnology., New Age International(P) Ltd., Publ., Mumbai. 2007
2. Deborah E. Bouchoux., 2005. Intellectual Property Rights. Delmar Cenage Learning.
3. The Indian Environmental Protection Act (EPA), 1986
4. Rules for manufacture, use/import/export and storage of hazardous microorganisms or cells Act, 1989
5. Food Safety and Standards act (Government of India), 2006

6. Singh, KC, 2016.Intellectual Property Rights on Biotechnology Central Law Agency..BCIL, New Delhi.
7. Eric Ries,.2020.The Lean Startup: How Constant Innovation Creates Radically Successful Businesses Kindle Edition
8. DhruvNath and SushanthoMitra. 2020. Funding for your Start ups:and other nightmares.Kindle edition.

Prctical 7

OMIC TOOLS FOR MICROBIAL BIOPROSPECTING

1. Survey of some genome, metagenome, proteome data bases.
2. nBLAST, pBLAST, Multiple Sequence Analysis
3. Gene Annotation of genome sequences (ORF finding)
4. Amplification of 16S DNA
5. Phylogenetic analysis using 16S rDNA typing
6. Study the Biodiversity of uncultured organisms using AFLP
7. Separation of protein affinity chromatography, Gel Filtration:
8. Native gel, SDS PAGE and 2D gel Electrophoresis

Unit	Unit Title	Intended Learning Chapters		Hours of Instructions
		KL & AL1	**AL2, EL & SL**	
Unit 1	**Databases**	Survey of some genome, metagenome, proteome data bases. nBLAST, pBLAST,	Multiple Sequence Analysis Gene Annotation of genome sequences	**12.5 hrs**
Unit 2	**Phylogenetic assay**	Study the Biodiversity of uncultured organisms using AFLP	Amplification of 16S DNA Phylogenetic analysis using 16S rDNA typing	**12.5**
Unit 3	**Proteomics**	, Gel Filtration: Native gel, SDS PAGE and 2D gel Electrophoresis	Separation of protein affinity chromatography	

Practical 8

BIOENGINEERING

1. To study effects of physiochemical factors on microbial growth
2. Determination of thermal death rate constant and decimal reductiontime for *E. coli.*
3. Cell disruption for endoenzymes by sonication,
4. Preservation of industrially important bacteria by lyophilization,
5. Extraction of Citric acid/Lactic acid by salt precipitation.
6. Separation of microbial biomass from culture medium,
7. Isolation of cell bound and intracellular product, Cell lysis and different methods,
8. Isolation and purification of a protein by salt and solvent precipitation,
9. Study the application of dialysis in downstream processing of a product,
10. Product recovery and purification by different chromatography techniques such as gel filtration, ion exchange chromatography and other chromatography,
11. Ultra filtration and its application in purification.

Unit	**Unit Title**	**Intended Learning Chapters**		**Hours of Instructions**
		KL & AL1	**AL2, EL & SL**	
Unit 1	**Cell disruption and preservation**	To study effects of physiochemical factors on microbial growth Determination of thermal death rate constant and decimal reduction time for *E. coli.* Cell disruption for endoenzymes by sonication,	Preservation of industrially important bacteria by lyophilization,	**12.5**
Unit 2	**Isolation**	Isolation of cell bound and intracellular product, Cell lysis and different methods, Isolation and purification of a protein by salt and solvent precipitation,	Isolation and purification of a protein by salt and solvent precipitation,	**12.5**
Unit 3	**Purification**	Ultra filtration	Product recovery and purification by different chromatography techniques such as gel	**12.5**

			filtration, ion exchange chromatography and otherchromatography, Ultra filtration and its application in purification.	

Research Project: 200M

Microbiology research has been and continues to be, central to meeting many of the current global aspirations and challenges, such as maintaining food, water and energy security for a healthy population on a habitable earth. Microbiology research has been and continues to be, central to meeting many of the current global aspirations and challenges, such as maintaining food, water and energy security for a healthy population on a habitable earth. The Industrial Biology curriculum provides a firm background in biology with emphasis on various molecular approaches in understanding biological phenomena, of culturing organisms for various industrial, pharmaceutical, and biotechnological uses, and of applying these in agriculture, industry, and the environment.