NIRMA UNIVERSITY

INSTITUTE OF SCIENCE

NAAC ACCREDITED 'A+' GRADE

M.SC. PROGRAMME 2026-2027

Teaching & Examination Scheme
Course Syllabus

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ANNEXURE-I

M.Sc. Biotechnology

Nirma University
Institute of Science
M Sc. in Biotechnology
Teaching & Examination Scheme

M. Sc. SEMESTER-I

w.e.f.: Academic Year 2026-27

Course Code	Course Title	Teaching Scheme (hours/week)						Examination Scheme			
		L	T	P	OLA	TH	C	Duration (hrs)	Component Weightage		
								SEE	CE	LPW	SEE
6SL105CC26	Cell and Molecular Biology	60	-	-	60	120	4	3	0.5	-	0.5
6SL305CC26	Immunology	60	-	-	60	120	4	3	0.5	-	0.5
6SL202CC26	Human Physiology	45	-	-	45	90	3	3	0.5	-	0.5
6SL402CC26	Microbiology	45	-	-	45	90	3	3	0.5	-	0.5
6SL203CC26	Metabolism	45	-	-	45	90	3	3	0.5	-	0.5
6SL102CC26	Laboratory I	-	-	150	-	150	5	-	1.00	-	-
6SL801CC26	Scientific Communications - I	15	-	-	15	30	1	-	1.0	-	-
	Total					**690**	**23**				

M. Sc. SEMESTER-II

w.e.f.: Academic Year 2026-27

Course Code	Course Title	Teaching Scheme (hours/week)						Examination Scheme			
		L	T	P	OLA	TH	C	Duration (hrs)	Component Weightage		
								SEE	CE	LPW	SEE
6SL403CC26	Industrial Microbiology & Fermentation Technology	45	-	-	45	90	3	3	0.5	-	0.5
6SL104CC26	Bioanalytical Techniques	45	-	-	45	90	3	3	0.5	-	0.5
6SL303CC26	Genetic Engineering	45	-	-	45	90	3	3	0.5	-	0.5
6SL204CC26	Human Genetics	45	-	-	45	90	3	3	0.5	-	0.5
6SL205CC26	Laboratory II	-	-	150	-	150	5	-	1.00	-	-
6SL802CC26	Scientific Communications - II	15	-	-	15	30	1	-	1.0	-	-
	Elective I	45	-	-	45	90	3	3	0.5	-	0.5
	Total					**630**	**21**				

Activities under Other Learning Activities Class test; Sessional Test; Semester End Examination;Assignment; Individual/Group presentations; Expert lectures; Guest lectures; Other Academic activities

M. Sc. SEMESTER-III

w.e.f.: Academic Year 2026-27

Course Code	Course Title	Teaching Scheme (hours/week)						Examination Scheme			
		L	T	P	OLA	TH	C	Duration (hrs)	Component Weightage		
								SEE	CE	LPW	SEE
7SL301CC27	Animal Biotechnology	45	-	-	45	90	3	3	0.5	-	0.5
7SL302CC27	Genomics & Proteomics	45	-	-	45	90	3	3	0.5	-	0.5
7SL303CC27	Plant Biotechnology	45	-	-	45	90	3	3	0.5	-	0.5
7SL901CC27	Research Methods	30	-	-	30	60	2	-	1.00	-	-
7SL204CC27	Laboratory III	-	-	120	-	120	4	-	1.00	-	-
	Elective II	45	-	-	45	90	3	3	0.5	-	0.5
	Elective III	45	-	-	45	90	3	3	0.5	-	0.5
	Total					**630**	**21**				

M. Sc. SEMESTER-IV

w.e.f.: Academic Year 2026-27

Course Code	Course Title	Teaching Scheme (hours/week)						Examination Scheme			
		L	T	P	OLA	TH	C	Duration (hrs)	Component Weightage		
								SEE	CE	LPW	SEE
7SL902ME27	Dissertation	-	-	450	-	450	15	3	0.5	-	0.5
7SL903ME27	Internship	-	-	450	-	450	15	3	0.5	-	0.5
	Total					**450**	**15**				

Elective I (*Semester II*)		**Elective II** (*Semester III*)		**Elective III** (*Semester III*)	
6SL106ME26	Nanobiotechnology	7SL401ME27	Agriculture & Environmental Microbiology	7SL216ME27	Molecular Medicine
7SL304ME26	Vaccinology	7SL409ME27	Microbiome in Health and Disease	7SL202ME27	Cancer Biology
6SL405ME26	Microbial Ecology	7SL215ME27	Structural Biology and Drug Discovery	7SL411ME27	Food and Dairy Microbiology

Activities under Other Learning Activities

Class test; Sessional Test; Semester End Examination; Assignment; Individual/Group presentations; Expert lectures; Guest lectures; Other Academic activities

SEMESTER I

Core Courses

L	T	P	C
4	-	-	4

Course Code	6SL105CC26
Course Title	Cell & Molecular Biology

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Understand and appraise the fundamentals of cell as a unit of living organisms and their organelles in terms of structure and functions.

CO2 Evaluate the cellular mechanisms of cell-cell interactions, cell communications, cell signalling pathways, molecular mechanisms and their crosstalk, cell division, cell death, and regulation Analyse the concept of central dogma and its updates

CO3 Demonstrate understanding of molecular processes and principles of DNA replication, transcription, translation, and regulation

Syllabus: **Teaching hours**: **60 Hours**

Unit 1: Plasma membranes; transport, Cell–Cell Adhesion and Communication **7 Hours**

Plasma membrane transport, structure & molecular composition of various transporters for active and passive transport, Cell-cell adhesions: Ca++ dependent and Ca++ independent; Extracellular matrix.

Unit 2: Cytoskeleton; intracellular protein traffic **8 Hours**

Actin, Intermediate Filaments and Microtubules; Structure, Dynamics, and functions of each in mitosis, cell movement; motor proteins and accessory proteins; Gated, Nuclear, and Vesicular protein traffic intracellular environment.

Unit 3: Cell Signaling **8 Hours**

Cell Surface Receptors; Signaling from Plasma Membrane to Nucleus, Map Kinase Pathways, G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, neurotransmission, and regulation

Unit 4: Cell Cycle **7 Hours**

Mitosis, Meiosis, Cell Cycle, Role of Cyclins and Cyclin Dependent Kinases, Regulation of Cdk –Cyclin Activity, Cell cycle check-points; necrosis, senescence, and apoptosis

Unit 5: DNA structure and Genome organization **7 Hours**

DNA structure and function: Central dogma, DNA as genetic material, DNA supercoiling, gyrases, topoisomerases; Physical properties of nucleic acids: Chromatin structure; Chromatin remodeling and its functional significance.

Unit 6: DNA Replication, repair, and recombination **8 Hours**

Mechanism of Prokaryotic and Eukaryotic DNA replication; DNA damaging agents; DNA repair - Components and pathways; DNA recombination Components and pathways.

Unit 7: Transcription **8 Hours**

Structure and function of mRNA; Mechanism of transcription in prokaryotes and eukaryotes; RNA processing: splicing, capping, polyadenylation, and base modifications; Prokaryotic gene regulation: Lac operon, Attenuation, antitermination, small RNAs, riboswitch.

Unit 8: Translation **7 Hours**

Structure and function of mRNA, rRNA, and tRNA; Genetic code; Ribosomes; Mechanism of translation in prokaryotic and eukaryotes; inhibitors of translational; post-translational modifications.

References:

1. Alberts, Bruce, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts and Peter Walter. Molecular Biology of the Cell. 7th Ed. New York: Garland Science, Taylor and Francis Group, LLC, 2022.
2. Gerald K., Cell and Molecular Biology, Concept and Experiment, 6th Edition, Wiley, 2013.
3. Kleinsmith, L. J. J. Principles of Cell and Molecular Biology, 2nd Edition, Benjamin Cummings, 1997.
4. Krebs, J. E., Lewin, B., Goldstein, E. S., & Kilpatrick, S. T. (2014). Genes, XI.
5. Lodish, H., Berk A., Kaiser C. A., Krieger M., Scott M.P., Bretscher A., Ploegh H., and Matsudaira P., Molecular Cell Biology, 6th Edition, Freeman, W. H. and Co., 2008.
6. Pollard, T. D., and Earnshaw, W. C., Cell Biology 4th Edition, Saunders Elsevier, 2023.
7. Stryer, L., Bery, J. M., Dymoczko, J. L., Biochemistry. 10th Edition, WH Freeman and Co. New York, 2023.
8. Watson, J. D., & Levinthal, C. (2014). Molecular biology of the gene, 7th Edition.

L	T	P	C
4	-	-	4

Course Code	6SL305CC26
Course Title	Immunology

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

- CO1 Develop good understanding on how immune system discriminate self-from non-self.
- CO2 Evaluate the immune response of the host encountering the pathogen or upon vaccination.
- CO3 Understand how MHCs play critical role in shaping specific adaptive immune responses
- CO4 Select target antigen or immunogen against which immune response is generated
- CO5 Develop strategies to regulate immune response against the self
- CO6 Design immunoassays based on the monoclonal antibodies

Syllabus: **Teaching Hours: 60**

Unit 1: Introduction **6 Hours**

Cells of the immune system, Hematopoiesis, structure and function of primary and secondary lymphoid organs, Innate immune system, PAMPs (pathogen associated molecular patterns), DAMPs (damage associated molecular patterns), PRRs (pattern recognition receptors), Antigen (immunogen, haptens and carrier).

Unit 2: Antibody and Complement **8 Hours**

Structure and functions of immunoglobulins, Isotypic, allotypic and Idiotypic variations; Complement activation and regulation.

Unit 3: Generation of Diversity **8 Hours**

Generation of antigen receptor diversity (VJ/VDJ recombination for BCR and TCR), somatic hypermutations, affinity maturation, B and T cell Development.

Unit 4: MHC and APP (antigen processing and presentation) **8 Hours**

Polymorphism of MHC genes, Role of MHC antigens in immune responses, MHC antigens in transplantation; Antigen-uptake, processing, presentation/cross-presentation.

Unit 5: Lymphocyte activation and trafficking **8 Hours**

B and T cell activation including signaling, differentiation, memory formation and recall, lymphocyte trafficking and immune surveillance

Unit 6: Cytokines **6 Hours**

Interleukins, monokines, transforming growth factors, chemokines, their receptors, signaling and functions.

Unit 7: Tolerance **8 Hours**

Autoimmunity, transplantation, allergy and hypersensitivity, cancer immunity, immune-deficiency.

Unit 8: Immuno-technology **8 Hours**

Immunodiffusion assay (radial diffusion, Ouchterlony double diffusion), RIA (radio immune assay), ELISA, Immune-PCR, Immunoblot, Immunocytochemistry, Immunoprecipitation, B cell and T cell hybridoma technology, Flow-cytometry, Single chain antibodies, CAR-T cell, CAR-N

References:

1. Janeway, C (2018) Janeway's immunobiology. Garland Science 11th Edition.
2. Kindt, T. J (2018). Kuby immunology. Macmillan. 8th Edition
3. Paul, W. E. (2012). Fundamental immunology. Lipincott & Wilkins, 8th Edition
4. Abbas, A. K., Lichtman, A. H., & Pillai, Shiva. (2017). Cellular and molecular immunology WB Saunders Co. Philadelphia, Pennsylvania, 186-204, 9th Edition
5. Coico, R. (2015). Immunology: A Short course. John Wiley & Sons, 7th edition
6. Peter J. Delves, Seamus J. Martin, Dennis R. Burton, and Ivan M. Roitt. (2017). Roitt's essential immunology John Wiley & Sons. 13th Edition.

L	**T**	**P**	**C**
3	**-**	**-**	**3**

Course Code	**6SL202CC26**
Course Title	**Human Physiology**

Course Learning Outcomes (CLO):

At the end of the course, students will be able to

- CO1 To identify basic organisation of biological system of the human body and define their role.
- CO2 To describe and relate the structure to functional role of each organ and organ system
- CO3 To comprehend interactions amongst various organs within/between system/s, their negative and positive feedback to maintain steady state and equilibrium in the body.
- CO4 To discuss, interpret and analyze biochemical alterations and evaluate the pathophysiological changes during diseased condition.

Syllabus: **Teaching hours**: **45**

Unit 1: Digestive System **9 Hours**

Digestive Processes; Structural organisation and functions of Alimentary Canal (GI tract); Structure and functions of salivary gland, teeth, pancreas, liver; Physiology of digestion and absorption. Diseases/Disorders of digestive system.

Unit 2: Cardiovascular System **9 Hours**

Structure and functions of blood — formed elements (blood cells) and plasma, physiology of blood coagulation. Grouping of blood; Basic structure of heart, conduction system and cardiac cycle; Organisational structure of blood vessels and lymphatic vessels. Diseases/Disorders of CVS.

Unit 3: Respiratory System **6 Hours**

Structural Organisation of Respiratory System: Structure and functions of nose, larynx, trachea, bronchi, and lungs; Physiology of Respiration (inspiration, expiration, pulmonary air volumes and capacities), Transportation of respiratory gases. Diseases/Diseases of Respiratory System.

Unit 4: Urinary System **9 Hours**

Anatomical Structure of functional unit of kidney (Nephron); Blood and nerve supply of kidney; Physiology of urine formation (glomerular filtration, tabular re-absorption, tabular secretion); characteristics of urine and its utility in measuring health states; Homeostasis. Diseases/Diseases of Urinary System.

Unit 5: Skeletal System **6 Hours**

Structural Organisation of Skeletal System — Axial and appendicular system; structure and types of bones; Articulations - fibrous, cartilaginous, and synovial joints; Types of Synovial joints (gliding, hinge, pivot, ellipsoidal, saddle and ball and socket joints). Diseases/Disorders of Skeletal System.

Unit 6: Muscular System **6 Hours**

Types, characteristic and functions of muscles (skeletal, smooth, and cardiac muscles); neuro muscular junctions; homeostasis and muscles (oxygen debt, muscle fatigue and heat production). Diseases/Disorders of Muscular System.

References:

1. Guyton, H., Textbook of Medical Physiology, Elsevier, 2000.
2. Tortora, G. J. and Derrickson, B. H., Principles of Anatomy and Physiology, Wiley and Sons, 2009
3. Gilbert, S. E., Developmental Biology, Sinauer Associates, 6th Edition, 2010.
4. Holes Human Anatomy and Physiology by David Shier, Jackie Butler, Ricki Lewis. McGraw hill Education 2015, 8th ed.
5. Essential of Human Physiology for Pharmacy by McCorry, Laurie Kelly, Boca Raton CRC Press 2008
6. Basic Anatomy: General Anatomy and Upper limg by Oommen Anitha, New Delhi Ane Books Pvt. Ltd. 2010
7. Anatomy & Physiology by Gerard Tortora J,Derrickson, Bryan., Delhi Wiley India (P) Ltd. 2014.
8. Anatomy & Physiology; workbook by Gerard Tortora J,Derrickson, Bryan., Delhi Wiley India (P) Ltd. 2014.

L	T	P	C
3	-	-	3

Course Code	**6SL402CC26**
Course Title	**Microbiology**

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CLO1 Get aquainted with the basic concepts of various fields of Microbiology, and also learn about growth pattern of microbes in different ecosystems.

CLO2 Acquire experimental knowhow of essential microbiological techniques e.g. microscopy, cultivation of microbes, etc.

CLO3 Develop an understanding of various facets of microbes and their applications eg. medical microbiology, industrial microbiology, agricultural microbiology, etc.

Syllabus: **Teaching Hours: 45**

Unit 1: Foundation in Microbiology **7 Hours**

A brief history of microbiology; Origin of life; Prokaryotic and Archaeal cell structures, Microbes in our lives

Unit 2: Microbial Diversity **8 Hours**

Archaea, Bacteria, Fungi, Algae, Protozoa, and Viruses

Unit 3. Microbiological Techniques **7 Hours**

Bacterial cell cycle, Methods for studying and culturing microbes; Theory and measurement of bacterial growth; Environmental factors affecting growth, Culture preservation and Culture collection centres.

Unit 4. Sterilisation, Disinfection and Antisepsis **7 Hours**

Control of microbial growth, physical methods of microbial control- principles of effective disinfection, types of disinfectants.

Unit 5. Principles of microbial systematics **8 Hours**

Taxonomic ranks, Microbial Taxonomy and phylogeny-classical and molecular characteristics, physiological methods to study microbial communities, Molecular methods to study microbial communities, Bergey's Manual of Systematic Bacteriology.

Unit 6. Applied Microbiology **8 Hours**

Overview of applications of microorganisms in agriculture, environment, energy, Food, medical, and industry sectors.

References:

1. Atlas, R. M. Principles of Microbiology 3rd Edition, Wm. C. Brown Pub., Iowa, USA, 2001.
2. Cavicchioli, R. Archaea – Molecular and Cellular Biology, ASM Press, Washington, 2007.
3. Dworkin, M., Falkow, S., Rosenberg, E., Schleifer, K.H., Stackebrandt, E. (Eds.). The Prokaryotes. Vol. I – VII, Springer, 2006.
4. Garrity, G.M. and Boone, D.R. (Eds.), Bergey's Manual of Systematic Bacteriology, 2nd edition, Vol. I, Springer, 2001.
5. Garrity, G.M., Brenner, D.J., Kreig, M.R. and Staley, J.T. (Eds.), Bergey's Manual of Systematic Bacteriology, 2nd edition, Vol. II, Springer, 2005.
6. Tortora GJ, Funke BR and Case CL. Microbiology: An Introduction. 9th edition, Pearson Education, 2008.
7. Madigan, M.T. and Martinko, J.M. Brock Biology of Microorganisms, 11th edition, Pearson Prentice Hall, 2006.
8. Mueller, G.M., Bills, G.F. and Foster, M.S. Biodiversity of Fungi – Inventory and Monitoring Methods, Elsevier Academic Press, 2004.
9. Willey, J.M., Sherwood, L.M. and Woolverton, C.J. Prescott, Harley and Klein's Microbiology, 7th edition, McGraw Hill, 2008.

L	T	P	C
3	-	-	3

Course Code	**6SL203CC26**
Course Title	**Metabolism**

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Understand the metabolic pathways - the energy-yielding and energy requiring reactions in life; understand the diversity of metabolic regulation, and how this is specifically achieved in different cells

CO2 Evaluate the different metabolic process occurring in the cells

CO3 Relate the link between the metabolic processes and their regulation as a response to external and internal factors

CO4 Analyse the differences and similarities between the various anabolic and catabolic processes occurring in the body

Syllabus: **Teaching Hours:45**

Unit 1: Metabolism of Carbohydrates **5 Hours**

Glycolysis, citric acid cycle, pentose phosphate pathways, glycogenesis and glycogenolysis and their regulation, Gluconeogenesis, and its regulation. Metabolism of Fructose and Galactose. Hormonal regulation of carbohydrate metabolism.

Unit 2: Metabolism of Lipids: **8 Hours**

Synthesis of various lipids, bile acids and cholesterol. Elongation of fatty acids, Desaturation of fatty acids in microsomes. Regulation of fatty acid synthesis, Cholesterol metabolism. Composition and synthesis of basic groups of Lipoproteins and their changes during transport in the body.

Unit 3: Metabolism of Amino Acids: **8 Hours**

General reactions of amino acid metabolism: transamination, oxidative deamination and decarboxylation. Catabolic fate of □-amino acids and their regulation, glucogenic and ketogenic amino acids. Urea cycle and its regulation. Amino acid biosynthesis.

Unit 4: Metabolism of Nucleotides: **8 Hours**

Biosynthesis of purines and pyrimidine- De novo and salvage pathways and their regulation. Catabolism of purines and pyrimidine. Biosynthesis of ribonucleotides and deoxyribonucleotides.

Unit 5: Enzymes: Basic Bio-thermodynamics **8 Hours**

Enzyme classification and nomenclature, Enzyme kinetics: Michaelis-Menten equation: Formula, Derivation and Significance; Alternate plotting procedures. Types of Inhibitors and their mode of action.

Unit 6: Enzyme Mechanisms and Regulation: **8 Hours**

Different mechanisms of enzyme activity; Strategies for enzyme regulation; Allosteric Enzymes and their Kinetics. Isoenzymes and Multienzyme Complexes.

References:

1. Voet, D., Fundamentals of Biochemistry, J. Wiley, 2008.

2. Voet, D. and Voet, J. G. Biochemistry, 3rd Edition. John Wiley and Sons, 2004. 3. Boyer, R., Concepts in Biochemistry, Brookes, 1999.
3. Metzler, D. E., Metzler, C. M., Biochemistry: the chemical reactions of living cells. Vols. I and II, Academic Press, 2001.
4. Nelson, D. C. and Lehninger, Principles of Biochemistry, Mac Millan, 2000.
5. Murray, R. K., Granner D. K., Mayes, P. A., Rodwell, V. W., Harper's Biochemistry, 27th Edition, McGraw Hill, 2006.
6. Stryer, L., Bery, J. M., Dymoczko, J. L., Biochemistry Only. 6th edition, WH Freeman and Co. New York, 2006.

L	T	P	C
-	-	10	5

Course Code	6SL102CC26
Course Title	Laboratory I

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Perform fundamental microbiological, biochemical and cell culture techniques.

CO2 Analyze and interpret the results of biochemical estimations and microbiological experimental data

CO3 Apply techniques to the advanced level practicals and dissertation carried out in further semesters.

Syllabus **Teaching Hours: 192**

1. 1. Introduction to human chromosome complement using Giemsa-stained metaphase cells.
2. Observation of mitotic cell division stages in onion root tip
3. Observation of meiosis stages using fixed slides
4. Demonstration of Short-term blood culture for metaphase chromosome preparation
5. Measurement of microscopic structures using micrometer
6. To study the effect of various parameters viz. inoculum size, aeration, etc. on bacterial growth through the growth curve experiment
7. Estimation of bacterial load in various environmental/ food samples through viable counting
8. Gram-staining
9. Bacteriophage isolation from sewage sample
10. Enzyme assay for Amylase under various conditions
11. Sample Preparation and Separation of Amino Acids, Lipids and Sugars by TLC.
12. Estimation of bio-molecules (Sugar, Protein, Cholesterol, Urea) by spectrophotometer
13. Isolation of Genomic DNA from E.coli
14. Isolation of Plasmid DNA from E.coli
15. Quantification and analysis of DNA
16. Regulation of lac operon in E.coli

References:

1. Patel, RJ. Experimental Microbiology. Vol-1, Aditya Publishers, India, pp: 60-61, 2009
2. Sherma, Joseph, and Bernard Fried, 2nd eds. Handbook of thin-layer chromatography. CRC press, 2007.
3. Stahl, Egon, 2nd eds. "Thin-layer chromatography: a laboratory handbook." Thin-layer chromatography: a laboratory handbook. 2007.
4. Cappuccino, James G., and Natalie Sherman, 7th eds. "Microbiology: A laboratory manual." Addision-six 1999 2007.
5. Mu, Plummer, and David T, 3rd eds. Plummer. Introduction to practical biochemistry. Tata McGraw-Hill Education, 2007.
6. Bates, Steven E. "Classical cytogenetics: karyotyping techniques." Human Pluripotent Stem Cells. Humana Press, 177-190, 2011..
7. Rao, Beedu Sashidhar and Deshpande, Vijay, Experimental Biochemistry, A student Companion, I. K. International Pvt. Ltd, 2005
8. Tom Maniatis, E. F. Fritsch, Joseph Sambrook, Molecular cloning-a laboratory manual, 3rd eds, Cold Spring Harbor Laboratory, 2001
9. Primrose, S. et.al., 7th eds. Principles of Gene Manipulation. Oxford: Blackwell Science, 2008 2001.
10. Prescott.L.M, 7th eds. Microbiology, McGraw Hill Publication, 2008
11. Mitosis, Meiosis and Genetics, J. L. Stein Carter & D. B. Fankhauser, Genetics, 2010.
12. Alberts, Bruce, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts and Peter Walter. Molecular Biology of the Cell. 6th ed. New York: Garland Science, Taylor and Francis Group, LLC, 2015.

Supplementary Course

L	T	P	C
1	-	-	1

Course Code	6SL801CC26
Course Title	Scientific Communication - I

Course Learning Outcomes*:*

At the end of the course, students will be able to-

CO1 Understand the basics of English grammar, phonetics, and mechanics of language
CO2 Use appropriate English vocabulary for fluent and confident communication in English
CO3 Demonstrate communication capacities in speaking, writing, listening, and narrating in English

Syllabus: **Teaching Hours: 15**

Unit 1: Introduction to communication

Idioms & Phrases, Basic Nonverbal communication, Barriers to Communication,

Unit 2: Business Communication at work place

Letter components and layouts, planning a letter, Process of Letter writing, Email Communication, Employment Communication, Notice Agenda and Minutes of Meeting

Unit 3: Report Writing

Effective Writing, Types of Business Reports, Structure of Reports, Gathering Information, Organization of Material, Writing Abstract and Summaries, Writing Definitions, Meaning of Plagiarism and Precaution.

Unit 4: Required Skill

Reading Skill, Note-Making, Precise Writing, Audio visual Aids, Oral Communication.

Unit 5: Mechanics of Writing

Transition, Spelling Rules, Hyphenation, Transcribing Numbers, Abbreviating Technical and Non-Technical Terms, Proof Reading.

References:

1. Technical Communication: Principles and Practice, by Meenakshi Raman and Sangeeta Sharma, Oxford University Press, IInd Edition

SEMESTER II

Core Courses

L	T	P	C
3	-	-	3

Course Code	6SL403CC26
Course Title	Industrial Microbiology & Fermentation Technology

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

CO1 Get acquainted with the industrial aspect of the field of Microbiology, and also learn about growth pattern of microbes in different industrial systems
CO2 Acquire experimental knowhow of microbial production of various industrial products such as alcohol, exopolysaccharides, enzymes, etc.
CO3 Develop an understanding of process control, upstream and downstream process.

Syllabus: **Teaching hours**:**45**

Unit 1: Overview of Microbial Fermentation Industry **7 Hours**

Range of fermentation processes; Diversity of microbes used as process organisms; Potential use of crude glycerol, and lignocellulosic hydrolysates as fermentation substrate with respect to sustainable development.

Unit 2: Screening and Strain Improvement **7 Hours**

Fundaments and concepts on screening of microorganisms for biotechnological applications; Genetic improvement of processes yielding microbial products.

Unit 3: Fermentor **8 Hours**

Design and Operation: Fundamentals of fermentation media and sterilization; Solid state and liquid state bioreactors; Bioprocess intensification and Scale-up.

Unit 4: Bioprocess Monitoring and Control **8 hours**

Biosensors; Bioprocess simulation and economics; Artificial intelligence in bioprocess industry

Unit 5 Downstream Processing **7 Hours**

Unit operations; Cell separation and disruption, product recovery and purification

Unit 6: Industrial Production of Representative Products **8 Hours**

Microbial production of organic acids, antibiotics, amino acids, ethanol, vitamins, enzymes, r-DNA products, probiotics, etc.

References:

1. Biochemical Engineering, Aiba, S., Humphrey,A.E. and Millis, N.F. Univ. of Tokyo Press.
2. Process engineering in Biotechnology, Jackson, A. T. Prentice Hall, Engelwood Cliffs.
3. Biochemical Reactors, Atkinson, B., Pion Ltd, London.
4. Fermentation Microbiology & Biotechnology, E L - Mansi and Bryce, Taylor & Francis, 1999.

5. Industrial Microbiology, Prescott & Dunn, Fourth Edition.
6. Industrial Microbiology by Casida. LE, New age International (P) Limited, Publishers.
7. Industrial Microbiology by Prescott & Dunns, AVI Publishing Company Inc.
8. Industrial Microbiology by A.H. Patel.
9. Principles of Fermentation Technology by P.F. Stanbury, A. Whitaker and S.J. Hall, Butterworth Heineman, Aditya Books (P) Ltd.
10. A text book of Industrial Microbiology by Wulf Crueger and Anneliese Crueger, Panima Publishing Corporation.

L	T	P	C
3	-	-	3

Course Code	6SL104CC26
Course Title	Bioanalytical Techniques

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Understand the principles and applications of various techniques used in the isolation, purification, and analysis of biomolecules.

CO2 Apply the concepts of modern anlaytical and instrumental techniques relevant to quantitative measurements in biology

CO3 Justify and relate the selection of bioanalytical methods to characterize a given sample

CO4 Critically evaluate the advantages, limitations, and prospects of various bioanalytical techniques

Syllabus: **Teaching hours:45**

Unit 1: Separation and characterization of macromolecules **8 Hours**

Principles and applications of ultracentrifugation, ultrafiltration, precipitation, and equilibrium dialysis; Horizontal and vertical electrophoresis. Native and SDS Polyacrylamide gel electrophoresis, 2 D electrophoresis

Unit 2: Chromatography **9 Hours**

Basic principles and applications of Paper chromatography, TLC, Gas Chromatography, Size exclusion chromatography, Ion-exchange chromatography, Affinity chromatography, Reverse phase chromatography, HPLC, FPLC

Unit 3: Spectroscopy **7 Hours**

Basic Principles and Applications of UV/Visible absorption, CD, Raman, Infrared, Fluorescence and Atomic Absorption Spectroscopy

Unit 4: Radioisotope Techniques **6 Hours**

Radioactive decay, half-life, Types of radiations, properties of α, β and γ rays, radioisotope tracer techniques, Measurement of radio activity, autoradiography, radiation protection and measurements, Applications of radioisotopes for analysis of biological samples

Unit 5: Structural determination of Biomolecules **8 Hours**

Basic Principle, instrumentation, and applications of Nuclear Magnetic Resonance & ESR, X-Ray Crystallography, Mass Spectrometry

Unit 6: Microscopy: **7 Hours**

Principles and applications of bright field, dark field, phase contrast, DIC etc., fluorescence, confocal, deconvolution, super-resolution, multiphoton, SEM, TEM, and various types.

References:

1. Pattabhi, V. and Gautham, N. Biophysics, Kluwer Academic Publishers, 2002.
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4. Hammes, G. G., Spectroscopy for Biological Sciences, John Wiley & Sons, 2005.
5. Westmeier, Reiner, Electrophoresis in Practice;Wiley-VCH Verlag Gmbh. 2005
6. Michael Hoppert; Microscopic Techniques in Biotechnology, John Wiley & Sons, Inc. 2006
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9. Wilson, K. and Walker, J. ; Principles and Techniques of Biochemistry and Molecular Biology, 7th edition, Cambridge University press., 2010
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12. Monk, Paul, Physical Chemistry: Understanding our Chemical World; John Wiley and Sons. 2013
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L	T	P	C
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Course Code	6SL303CC26
Course Title	Genetic Engineering

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Understand the fundamental concept of genetic engineering

CO2 Analyse the technique of genetic engineering

CO3 Apply the concept and techniques in designing and conducting experiments and research

Syllabus: **Teaching hours**: **45**

Unit 1: Fundamental Tool and Technique in Recombinant DNA Technology: 5 Hours

Restriction endonucleases (RE), ligases, alkaline phosphatase, polynucleotide kinase, methylases, terminal transferases, DNase, reverse transcriptase, blunt end ligation strategies, adapters, linkers, homopolymer tailing, RE independent cloning strategies. DNA polymerase I, Klenow fragment, nick translation, nucleotide probes, and their applications.

Unit 2: Cloning Vehicles and their Application: 8 Hours

Cloning vectors, Definition, and properties of cloning vectors - plasmids, bacteriophage lambda and M13 - based vectors, cosmids, and shuttle vector, YAC and BACs, viral vector (SV40, retrovirus, and Adenovirus), Ti and Ri Plasmids, cloning of PCR product, TA, and TOPO cloning, subcloning and GATWAY cloning.

Unit 3: Genomic and cDNA Library: 8 Hours

Strategies for Construction of Genomic library, Construction of cDNA library- mRNA enrichment, Reverse transcription, Selection, and screening of recombinant clones- screening of genomic and cDNA libraries

Unit 4: Gene manipulation and in-vitro mutagenesis: 8 Hours

Gene knockdown and knockout, Zinc Finger Nucleases (ZFN), CRISPR/Cas9, TALEN, RNAi, and antisense, site-directed mutagenesis, protein Engineering, and transposon tagging.

Unit 5: Expression Strategies for Heterologous Genes: 8 Hours

DNA Transfection methods, Reporter gene assays, Expression systems (Bacteria, Yeast, Insect, and mammals).

Unit 6: Application of DNA Recombinant Technology: 8 Hours

Biopharming, genetically modified organisms (microbes, plants, and animals) and their applications in medicine, agriculture, and industry; Gene mapping, therapies for genetic diseases, Ethical considerations, regulatory frameworks in gene editing and genetic engineering.

References:

1. Brown, T.A. (2020). Gene Cloning and DNA analysis. 8th Ed. Wiley Blackwell UK.
2. Primrose, S.B., & Twyman, R.M. (2014). Principles of Gene Manipulation and Genomics. Seventh Edition. Wiley Blackwell UK.
3. Sambrook, J., Fritsch, E. F., & Maniatis, T. (1989). Molecular cloning: a laboratory manual, Vol I, II and III. Cold Spring Harbor Laboratory Press. 3rd revised edition.
4. Watson JD. Caudy AA. Myers RM., Witkowski JA. (2007) Recombinant DNA: Genes and Genomes—A Short Course.
5. Nicholl, D. S. (2008). An introduction to genetic engineering. Cambridge University Press.

L	T	P	C
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Course Code	6SL204CC26
Course Title	Human Genetics

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Understand and appraise the fundamental principles of inheritance, structural and functional aspects of cellular genetic material

CO2 Learn collecting and interpreting genetic related history, making pedigree chart, interpretation of findings of genetic analysis, linkage, and association prediction studies

CO3 Evaluate various methods of genetic analysis for nuclear and mitochondrial genome, use of models of single gene, complex, and multifactorial disease conditions

CO4 Demonstrate understanding of available knowledge and can employ them by making use of various updated databases related to human genetic, genomic, phenotypic, and genetic conditions

Syllabus: **Teaching Hours:45**

Unit 1: Mendelian principles of inheritance 9 Hours

Dominance, segregation, independent assortment; alleles, multiple alleles, pseudo-allele, complementation tests; Extensions of Mendelian principles: Codominance,

incomplete dominance, gene interactions, pleiotropy, genomic imprinting, penetrance, and expressivity, phenocopy, linkage and crossing over, sex linkage, sex limited and sex influenced characters

Unit 2: Organization of human genome and genes **6 Hours**

Mitochondrial Genome organization, extra chromosomal inheritance, Inheritance of Mitochondrial and chloroplast genes, maternal inheritance, mitochondrial mutations, and myopathies. Overlapping genes, genes within genes, multigene families, pseudo genes, truncated genes, and gene fragments

Unit 3: Gene mapping **10 Hours**

Population genetics and genome wide association study, Sample size calculation, Principal Component Analysis, Polygenic Risk Score, LOD score for linkage testing, linkage maps, tetrad analysis, mapping with molecular markers, somatic cell hybrids; strategies in identifying human disease genes in pre and post Human Genome project; low- and high-resolution mapping; Principles and strategies for identifying unknown disease or susceptibility genes

Unit 4: Role of familial history collection and pedigree analysis **6 Hours**

Conventions of preparing pedigree charts, study of inheritance pattern, Pedigree analysis; standard norms of genetic counselling, ethical and other aspects of possible genetic discrimination, pre, and post-genetic test counselling

Unit 5: Cytogenetics and other methods of detection of genetic aberrations **7 Hours**

Human chromosomes classification, Molecular cytogenetic techniques, Fluorescence in situ hybridization, Multiplex FISH and spectral karyotyping, MLPA, Optical Genome Mapping, comparative genomic hybridization, SNP and other types of microarray, Whole Exome and Whole Genome sequencing, ISCN guidelines, ACMG guidelines.

Unit 6: Data Mining in Genetics Research & Clinical Management **7 Hours**

Introduction to Internet based cataloguing of Genetic Aberrations in various genetic diseases, OMIM, COSMIC, Clinvar, Human Variome project, Human Phenome project, Encode project, Genome Databases, and their significance (GenBank, Ensemble, DDJB etc). Genome Variant Databases, Variant Data Analysis, Exomizer, Variant Effect Predictor, and In silico Variant Functional Analysis (Polyphen2, SIFT, PROVEAN, Mutalyzer, Mutation Taster, Mutation Assessor, Human Splice Finder, etc). Phenomizer and other automation approaches in phenotyping.

References:

1. ISCN 2016, Jean McGowan-Jordan, A. Simons, M. Schmid; Karger, 2016
2. Rooney D. E., and Czepulkowski, B. H., Human Cytogenetics: A Practical Approach (Vol. I & II), 1992 Edition, Oxford University Press, 1992.
3. Griffith A. J.F., Wessler S.R., Carroll, S.B., and Doebley J., Introduction to Genetic Analysis, 10th Edition, W. H. Freeman, 2010.
4. Benjamin P., Genetics: A Conceptual Approach & Problem Solving, 2008, W. H. Freeman, 2008.
5. Hedrick, P. W. (2011) Genetics of Populations, 4th Edn., Jones & Bartlett Publ.
6. Vogel and Motulsky's Human Genetics: Problems and approaches, Michael R. Speicher, Stylianos E. Antonarakis, Arno G. Motulsky, Springer; 4th ed. 2010 edition.
7. The AGT Cytogenetics Laboratory Manual, M.J.Barch, T.Knutsen, and J.Spurbeck.,Third Edition,Lippincott-Raven Publishers, Philadelphia (1997)
8. Genomic Imprinting and Uniparental Disomy in Medicine by Eric Engel, Stylianos E. Antonarkis, Wiley-Liss, Inc. ISBNs: 0-471-35126-1 (Hardback); 0-471-22193-7
9. Ricki Lewis Human Genetics Concepts and Applications 10th Edition, 2011, McGraw-Hill Science.
10. The Science of Genetics, Atherly et al (1999), Saunders
11. Robbins & Cotran, Pathologic Basis of Disease, 8th Edition, Elsevier, 2010.
12. Strachan Tom and Read Andrew P. (2011) Human Molecular Genetics, 4th Edition, Garland Science (Taylor and Francis Group), London and New York

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Course Code	6SL205CC26
Course Title	Laboratory II

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Understand the basics of bioinformatics tools, immunological techniques, Industrial microbiology, microbial genetics and experiments related to molecular biology

CO2 Analyze the data obtained from molecular analysis of RNA, DNA and protein

CO3 Apply the techniques based on requirement in analysis of biomolecules and microbiology and for conducting research

Syllabus:	Teaching hours: 150

1. Introduction to bioinformatics, computational biology, Genomics, Proteomics
2. Introduction to Biological Databases and Data Retrieval Tools
3. To perform database similarity search of given nucleotide sequence using BLAST
4. Introduction to and Retrieval of protein structures from the PDB
5. To learn searching using PubMed: The Bibliographic Database
6. To learn drawing chemical compound structures
7. Performing Multiple Sequence Alignment with Clustal Omega
8. To isolate genomic DNA from bacteria by CTAB method
9. To resolve the purified samples of plasmid and genomic DNA using agarose gel electrophoresis
10. Study of Polymerase Chain Reaction (PCR)
11. Plasmid DNA isolation from E.coli using alkaline lysis method
12. Perform direct ELISA (Enzyme Linked Immuno-Sorbent Assay)
13. Purification of IgG by Ion-exchange chromatography
14. Purification of IgG by Affinity chromatography
15. Perform Western Blot
16. RNA isolation
17. cDNA Synthesis and qPCR
18. To isolate antibiotic resistant mutants
19. To produce citric acid fermentatively by Aspergillus niger and carry out its crude recovery and estimation
20. Alcohol fermentation from grapes, molasses,etc. and Alcohol Estimation
21. Protocol for isolation and cultivation of heterotrophic bacteria from water samples
22. Qualitative assessment of enzyme activity in microorganisms isolated from water samples
23. Biofilm Quantification from Heterotrophic Bacterial isolates.

Supplementary Courses

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Course Code	6SL802CC26
Course Title	Scientific Communication - II

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Develop novel topics about which they wish to communicate

CO2 Use electronic databases to perform literature searches for information

CO3 Synthesize this information and information from other sources to formulate clear, logical theses and arguments about their topics

Syllabus: **Teaching Hours:15**

Unit 1: Scientific Communications **7 Hours**

Importance of communication in science, Types of communications, Communicating with scientific and non-scientific audiences, Verbal, and presentation skills: Oral and Poster Presentations, Graphical abstract.

Unit 2: Writing Skills **8 Hours**

Writing of Books and Research Papers, Report and thesis Writing, Formats of Publications in Research Journals

References

1. Scientific Communication- An introduction https://doi.org/10.1142/11541 | March 2020, pages 276
2. Science communication: A practical Guide for scientists, Laura Bowater, Kay Yeoman, ISBN: 978-1-118-40666-3 October 2012 Wiley-Blackwell
3. Joseph E. Harmon and Alan G. Gross. The Craft of Scientific Communication. University of Chicago Press; 2010.

Elective Courses I

L	T	P	C
3	-	-	3

Course Code	6SL106ME26
Course Title	Nanobiotechnology

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Understand the basics of nanotechnology and biomaterials

CO2 Understand the different types of formulation and factors affecting them

CO3 Analyse the Biological Interactions with nanomaterials

CO4 Evaluate the risk assessments involved bio nano materials

Syllabus: **Teaching Hours:45**

Unit 1: Basics of Nanobiotechnology 8 Hours

Origins of nanotechnology, Definitions and scales, size scale effects; Current state of Nanotechnology, Future of Nanotechnology; Nanotechnology in Nature and applications; Nanotechnology in Biology; Mechanism of biological systems at nanoscale; biological motors, Biophotonic devices, Introdution to DNA Nanotechnology.

Unit 2: Sustained, Controlled Release formulation and Nano-Based Drug Delivery System 8 Hours

Introduction & basic concepts, factors influencing, Physicochemical & biological approaches for SR/CR formulation, Mechanism of Drug Delivery from SR/CR formulation, Customized drug delivery systems; Polymeric Micelles, Solid Lipid Nanoparticles, their types, Synthesis, Characterization, and applications.

Unit 3: Nanomaterials and Biomaterials 8 Hours

Molecular building blocks for nanostructure systems, Nanomaterials – formation of materials, carbon nanomaterials, Buckyball, Graphene (2D), Carbon nano tubes, Inorganic nano materials, Zero Dimensional Nano-Structures, One Dimensional Structures, 2D and 3-D Structures; Properties of biomaterials, Surface, bulk, mechanical and biological properties. Scaffolds & tissue engineering, Types of biomaterials, example of biological and synthetic materials, Biopolymers, Liposomes, Applications of biomaterials, Modifications of Biomaterials.

Unit 4: Models of Nano and Bionanosystems 7 Hours

Lipid Bilayers, liposomes, neosomes, Phytosomes, Polysacharides, Peptides, Nucleic acids, DNA scaffolds, Enzymes - Biomolecular motors: linear, rotary motors. Immunotoxins, Membrane transporters and pumps, Antibodies, monoclonal Antibodies, immunoconjugates. Limitations of natural biomolecules.

Unit 5: Biological Interactions with Materials and Bioaccumulation 7 Hours

Biocompatibility, Cellular uptake mechanisms; Granulation Tissue Formation, Foreign body reaction, Fibrosis, Blood-Biomaterial interactions, Interactions with Proteins, , The Vroman Effect, Fibrous Capsule Formation, Safety Testing of Biomaterials. Exposure mechanisms, Subcellular localization, biodistribution, clearance mechanism, metabolism, and excretion of nanomaterials.

Unit 6: Regulatory Considerations for Drug Delivery Systems 7 Hours

Indian drug regulatory authorities, FDA, Drugs and Cosmetics Act, ICH and OECD Guidelines, Regulatory aspects of pharmaceutical and bulk drug manufacture, regulatory drug analysis; Predictive Nanotoxicology using QSAR and QSPR models, Immunotoxicity of nanomaterials.

References:

1. Bernard N. Kennedy (editor). New York: Nova Science Publishers, 2008.Stem cell transplantation, tissue engineering, and cancer applications
2. Biomaterials: A Nano Approach,S Ramakrishna, M Ramalingam, T.S. Sampath Kumar, Winston O. Soboyejo,Published by CRC Press
3. Bionanotechnology: Lessons from Nature, D S. Goodsell, by John Wiley & Sons, Inc.
4. Chris Binns, “Introduction to Nanoscience and Nanotechnology”, John Wiley and Sons 2010
5. Fadeel, B (2015): Handbook of Safety Assessment of Nanomaterials: From Toxicological testing of Personalized Medicine, Stanford Publishing, Singapore.
6. Fenghua Meng, Zhiyuan Zhong and Jan Feijen (2009): Stimuli-Responsive Polymersomes for Programmed Drug Delivery. Biomacromolecules, Biomacromolecules, 10(2): 197-209.
7. Fritz Allhoff, Patrick Lin, and Daniel Moore, “What Is Nanotechnology and Why Does It Matter” WILEY BLACKWELL A John Wiley & Sons, Ltd., Publication, 2010
8. James Swarbrick (2010). Novel Drug Delivery Systems. Informa healthcare
9. Kreuter J. (2012): Colloidal Drug delivery System, Marcel Dekker, USA.
10. Mark A. Reed and Takhee Lee, “Molecular Nano electronics”, American Scientific Publishers, 2003.
11. Naik J (2015). Nano Based Drug Delivery. IAPC Publishing, Zagreb, Croatia
12. Nanobiotechnology: Concepts, Applications and Perspectives, (edited by C. M. Niemeyer and C. A. Mirkin), Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim,
13. Nanobiotechnology: Concepts, Applications and Perspectives, Edited by Christof M. Niemeyer and Chad A. Mirkin, Wiley-VCH, 2004.
14. Nanofabrication towards Biomedical Applications, Techniques, Tools, Applications, and Impact. C. S. S. R. Kumar, J. Hormes, C. Leuschner, 2005, WILEY - VCH Verlag GmbH & Co. KGaA
15. Nanoparticulates Drug Carriers, Edited by Vladimir P Torchilin, 2006, Imperial College Press, 57 Shelton Street, Covent Garden.

16. Nanoscale Technology in Biological Systems, Edited by Ralph S. Greco, Fritz B. Prinz, R. Lane Smith, CRC PRESS, Boca Raton London New York Washington, D.C. Copyright © 2005 by Taylor & Francis
17. R. Lanza, I. Weissman, J. Thomson, and R. Pedersen, Handbook of Stem Cells, TwoVolume, Volume 1-2: Volume 1-Embryonic Stem Cells; Volume 2-Adult &Fetal Stem Cells, 2004, Academic Press.
18. R. Lanza, J. Gearhart etal (Eds), Essential of Stem Cell Biology, 2006, ElsevierAcademic press.
19. Ranade VV and Cannon JB (2015). Drug Delivery Systems. CRC Press.
20. Raphael Gorodetsky, Richard Schäfer. Cambridge: RSC Publishing, c2011.Stem cell based tissue repair.
21. Robinson JR, Lee VHL (2013). Controlled Drug Delivery Systems, Marcel Dekker, USA.

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Course Code	7SL304ME26
Course Title	Vaccinology

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Have an idea about the history of various vaccines (subunit vaccines, peptide, DNA and RNA vaccines, live & killed vaccines, and edible vaccines), composition of vaccines

CO2 Learn and develop understanding on the effective delivery of developed vaccine formulation to achieving robust immune responses

CO3 Understand the various methods to develop vaccines against viral diseases including, HIV, hepatitis, flu etc.

CO4 Learn and understand the basics of bacterial, protozoan vaccines with reference to malaria parasite

CO5 To design an efficacious vaccine based on our understanding of the immune response generated due to natural infection as well as the same induced by successful vaccines tried in human beings since 18th century.

Syllabus: **Teaching hours**: **45**

Unit 1: Classification of Vaccines 7 Hours

History of vaccines, Immunological principles, Composition of vaccines: vaccine, adjuvant, conservative Concepts of vaccine development, types of vaccine (Conventional vaccines; Live attenuated and killed vaccines; Subunit vaccines; Synthetic peptide vaccines; Anti-idiotype vaccines; Recombinant DNA vaccines; Deleted mutant vaccines; Reassortment vaccines; DNA vaccines; mRNA vaccines, Edible vaccines, heat killed, X-irradiated, or live attenuated whole pathogen, toxoid vaccines, challenges and possibilities with new vaccines and vaccine strategies

Unit 2: Adjuvants and Mucosal Vaccine Delivery 6 Hours

Novel adjuvants (targeting TLR and non-TLR based PRRs, metabolic adjuvants, cell death adjuvants, epigenetic adjuvants), vaccine formats (DNA, viral vectors, dendritic cells), Immunobiology of classic adjuvants with examples: Alum, emulsion adjuvants, Carriers; Haptens; Vaccine delivery methods and delivery mechanisms: nanoparticles, polymeric biomaterials, targeted delivery mechanisms, virus-like particles (VLP) and self-assembling peptide scaffolds.

Unit 3: Vaccines for viruses 8 Hours

HIV, CMV, Influenza, Hepatitis, herpes viruses, Conventional vaccines killed and attenuated, modern vaccines: recombinant proteins, subunits, DNA vaccines, peptides, immunomodulators (cytokines), Antisense RNA, siRNA, ribozymes, in silico approaches for vaccine design.

Unit 4: Vaccine for bacteria and parasites 8 Hours

Shigella, vibrio cholera, diphtheria, tetanus, pertusis, pneumococcus meningitis, mycobacterium (BCG), toxoplasma; Malaria, Leishmaniasis, Entamoeba histolitica, schistosomiasis and other helminthic infections

Unit 5: Antigen Prediction for B and T cells and Validation 8 Hours

Fundamentals of B cell and T cell epitope recognition, Databases in Immunology, linear and conformational B-cell epitope prediction methods, T-cell epitope prediction methods, Resources to study antibodies, antigen-antibody interactions, QAM (Quantitative Affinity matrix), Structure Activity Relationship – QSARs and QSPRs, QSAR Methodology, Methods for validating predicted B and T cell epitopes.

Unit 6: Vaccine Development and Standardization 8 Hours

Vaccine development pathway (vaccine design, pre-clinical studies, clinical trials (phase-I, phase-II and phase-III), vaccine registration, post-market surveillance, vaccine efficacy and vaccine effectiveness, standardization of vaccines, vaccine characterization, potency, stability, sterility and safety.

References:
1. Plotkin, S. A., Orenstein, W. A., and Offit, P. A., Vaccines. 5th Edition, Elsevier, 2008.
2. Immunopotentiators in Modern Vaccines by Schijns and O'Hagen
3. Robinson, A., Hudson, M.J., Cranage, M.P. Vaccine Protocols, C Second Edition, Humana Press, NY, 2003.
4. Chimeric Virus like Particles as Vaccines. Wolfram H. Gerlich (Editor), Detlev H. Krueger (Editor), Rainer Ulrich (Editor), November 1996 Publisher: Karger, S. Inc
5. Kindt, Kuby-Immunology (complements)
6. Current protocols in Immunology
7. Complement regulators and inhibitory proteins. Nat immunology Review volume 9, Oct 2009, 729-40

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Course Code	6SL405ME26
Course Title	Microbial Ecology

Course Learning Outcomes:

At the end of the course, the student will be able to

CO1 Understand principles of ecology and interactions among microorganisms and different environment

CO2 Analyze beneficial and pathogenic interactions of microorganisms with plants and animals

CO3 Importance of microbial diversity and conservation

CO4 Comprehend role of microorganisms in biogeochemical cycling of elements

Syllabus: **Teaching Hours: 45**

UNIT I: Fundamentals of Ecology 7 Hours

The basic concept of ecosystem, habitat and niche; energy in ecological systems; energy partitioning in food chains and food webs; history and scope of ecology.

UNIT II: Microbial interaction in Biotic and Abiotic Environment 6 Hours

Interaction between diverse microbial population in biotic environments; Conflictual interactions – parasitism - predation - antibiosis – competition; Beneficial interactions – co-metabolism – mutualism – cooperation – commensalism; Microbial interactions in abiotic environments.

UNIT III: Interactions between Microorganisms and Plants & Animals 8 Hours

Interaction with plant roots–rhizosphere & mycorrhizae; microbial diseases of plants. Microbial contribution to animal nutrition; novel prokaryotic endosymbionts, ecological aspects of animal diseases.

UNIT IV: Importance and Conservation of Microbial Diversity 8 Hours

Importance of microbial diversity in environment, pharmaceuticals & human health. Importance of conservation. Metagenomics. *In situ* conservation and *Ex situ* conservation. Role of culture collection centers in conservation.

UNIT V: Biogeochemical cycling I 8 Hours

Carbon cycle, Hydrogen cycle, Oxygen cycle

UNIT VI: Biogeochemical cycling II 8 Hours

Nitrogen cycle, Sulphur cycle, Phosphorus cycle, cycling of other elements

References:
1. Environmental Microbiology and Biotechnology by Singh and Dwivedi. New Age Int. Sci. Publication.
2. Atlas, R.M. and Bartha, R. Microbial Ecology, 4th edition, Pearson Education, 2009.
3. Maier, R.M., Peppper, I.L. and Gerba, C.P. Environmental Microbiology, 2nd edition, Elsevier Academic Press, 2009.
4. Paul and Clerk, Soil Microbiology and Biochemistry, 2007.
5. Paul, E.A. (Ed.). Soil Microbiology, Ecology and Biochemistry, 3rd edition, Academic Press, 2007.
6. Pepper, I.L. and Gerba, C.P. Environmental Microbiology – A Laboratory Manual, 2nd edition, Elsevier Academic Press, 2005.
7. Manahan, S.E. Environmental Chemistry, 9th edition, CRC Press, 2010.
8. Odum, E.P. and Barrett, G.W, Fundamentals of Ecology, 5th edition, Cengage Learning, 2005 Microbial Ecology by Alexander. Willey Publication.
9. Oladele Ogunseitan (2004) Microbial Diversity: Form and Function in Prokaryotes; Wiley- Blackwell.
10. Satyanarayana, T., Johri, B. N. (2005) Microbial Diversity: Current Perspectives and Potential Applications; I.K. International Publishing House Pvt., Limited.
11. James W.Brown (2014) Principles of Microbial Diversity; ASM Press.
12. Colwell, R. R., Simidu, Usio, Ohwada, Kouicki (1996) Microbial Diversity in Time and Space; Springer.

SEMESTER III

Core Courses

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Course Code	7SL301CC27
Course Title	Animal Biotechnology

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Describe the basics of maintenance of mammalian cell and generation of cell line using proper sterile techniques and optimum conditions of growth to develop mammalian cells

CO2 Identify and comprehend experimental knowhow of various techniques involved in cell separation and quantitation using latest technology

CO3 Relate and evaluate the applications of animal biotechnology gene therapy, toxicity testing, cancer research, animal breeding, vaccine production and other biotechnological products of industrial and medical benefits.

CO4 Relate to the social, cultural, economic, legal issues associated and comprehend the need Bioethics and IPR in biotechnological research

Syllabus: **Teaching hours**: **45**

Unit 1: The Culture Media for Animal Cell culture **9 Hours**

Introduction, history, and concept of biotechnology. Media and Supplements, Serum, Serum Free Media, Natural Media, Feeder Layer on Substrate, Gas Phase for Tissue Culture. Source of Tissue, Primary culture. Stages of Commitment and Differentiation, Proliferation, Malignancy.

Unit 2: Subculture and Cell lines **9 Hours**

Cross Contamination, Terminology, Naming and Choosing cell line and its maintenance. Criteria for subculture, growth cycle and split ratio, propagation in suspension and attached culture.

Unit 3: Cloning and hybridoma technology **6 Hours**

Vectors and Cloning, Somatic Cell Fusion, Hybridomas, HAT Selection, Medium, Suspension Fusion, Selection of Hybrid Clones, Organ Culture, Tumorigenesis

Unit 4: Cell Separation and Quantitation **9 Hours**

Separation techniques based on density, size, sedimentation velocity, antibody-based techniques - immune panning, magnetic sorting, and fluorescence activated cell sorting. Quantitation- Cell counting, cell weight, DNA content, protein, rate of synthesis, measurement of cell proliferation.

Unit 5: Characterization and differentiation **6 Hours**

Authentication, Record keeping, Provenance, parameters of characterization, Lineage and Tissue markers, cell morphology, Karyotyping, Chromosome banding. Differentiation- commitment, terminal differentiation. Lineage selection, proliferation and differentiation, commitment and lineage, markers of differentiation, induction of differentiation, cell interaction- homotypic and heterotypic. Cell – matrix interaction.

Unit 6: Applications of animal biotechnology and related problems **6 Hours**

Artificial animal breeding, cloning and transgenic animals, medicines, vaccines, diagnosis of diseases and disorders, gene therapy forensic application. Social, Cultural, Economical, Legal problems. Bioethics. IPR.

References:

1. Freshney, I., Cultures of Animal Cells, John Wiley and Sons Inc, 2010.
2. Cibelli, J., Robert P., Keith L.H.S., Campbell H., and West M. D., (Editors) Principles of Cloning, St. Diego Academic Press, 2002.
3. Mathur, S., Animal Cell and Tissue Culture, Agrobios (India), 2000.
4. Panno, J., The New Biology Series: Animal Cloning, Viva books Pvt. Ltd, New Delhi, 2010.
5. Mepham B. M., Bioethics- An introduction for Bioscience by, 2nd Edition, Oxford University Press, 2008.
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7. Satheesh, M. K. Bioethics and Biosafety, I.K. International Publishing House Ltd, New Delhi. 2005
8. Glick, B. R., and Pasternak J. J., Molecular Biotechnology - Principles and applications of recombinant DNA, ASM Press , 3rd Edition., 2003.
9. Sullivan, S., Cowen C., and Eggan K., Human Embryonic Stem Cell: The Practical Handbook, 2007.
10. Freshney, R. I. (2010) Culture of Animal Cells, 6th Edn., Wiley-Blackwell.
11. Ramadass, P, Animal Biotechnology: Recent Concepts and Developments
12. Portner, Ralf. Animal Cell Biotechnology: Methods and Protocols.

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Course Code	7SL302CC27
Course Title	Genomics and Proteomics

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Describe the understanding of origin and evolution of genomics and gene mapping

CO2 Apply the knowledge to establish new, molecular classification of the disease

CO3 Evaluate the possibilities for application of pharmacogenomics and proteomics in drug discovery and development of personalized medicine

Syllabus: **Teaching Hours: 45**

Unit 1: Origin and Evolution of genomics and gene mapping — **8 Hours**

Origin of genomics, the first DNA genomes, genomes and human evolution, evolution of nuclear, mitochondrial and chloroplast genome, the concept of minimal genome and possibility of synthesizing it, genetic maps, physical maps, functional maps, comparative genomics, and collinearity, synteny in maps.

Unit 2: Whole Genome sequencing technologies and genome assembly — **8 Hours**

Principle of genome sequencing tools, automated Sanger sequencing, pyrosequencing, Illumina. oxford nanopore and PacBio Sequencing. Whole genome assembly pipeline. k- Mer de Bruijn graph. Human, Arabidopsis, and Drosophila genome

Unit 3: Functional genomics — **6 Hours**

Concept of forward and reverse genetics, insertion mutagenesis (T-DNA and transport insertion), Targeting Induced Local Lesions in Genomes (TILLING), gene expression and transcript profiling, EST contigs, use of DNA chips and microarrays

Unit 4: Principle of basic protein preparation and separation — **8 Hours**

Preparation of protein isolates and fractionation /separation of proteins and peptides - basic methods of protein isolation from various sample types; electrophoretic separation techniques (IEF, SDS-PAGE, 2-D gel electrophoresis, DIGE, etc.); liquid chromatography (HPLC and FPLC); separation procedures for analysis of phospho-proteins and glycosylated proteins: multidimensional procedures for analysis of complex protein samples.

Unit 5: Strategies for protein identification — **8 Hours**

Mass-spectrometry of proteins - basic types of ionization techniques (ESI and MALDI) and hybrid instruments (TOF, ion trap and FTMS); protein identification methods; characterization of protein modifications. methods of protein quantification (relative and absolute quantification techniques)

Unit 6: Protein interactomes and protein modification in Proteomics and application — **7 Hours**

Methods of protein-protein interaction study (Y2H, tagging TAP, FLAG, His; ion mobility utilization); Phosphoproteomics, Glycoproteomics, protein microarray. Human proteome project. application of proteomics in diagnostic, drug development and agriculture.

References:

1. Pevsner, J., Bioinformatics and Functional Genomics, Second Edition, Wiley-Blackwell, 2009.
2. Mount, D. W., Bioinformatics: Sequence and Genome Analysis, CBS Publishers, 2004
3. Liebler, D., Introduction to Proteomics: Tools for New Biology, Human Press Totowa, 2002.
4. Campbell, A.M. & Heyer, L.J., Discovering Genomics, Proteomics and Bioinformatics. Benjamin/Cummings, 2002.
5. Twyman, R. Principles of Proteomics. London: Taylor & Francis, 2014.
6. Lovric J. Introducing Proteomics: From Concepts to Sample Separation. Mass Spectrometry and Data Analysis, published by Wiley, 2011

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Course Code	7SL303CC27
Course Title	Plant Biotechnology

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Explain the basic concepts and historical development of plant biotechnology.

CO2 Apply tissue culture techniques for plant regeneration and micropropogation.

CO3 Analyze different methods used for genetic transformation in plants.

CO4 Evaluate Plant selection and molecular markers and for plant improvement.

CO5 Describe the industrial and environmental applications of plant biotechnology besides biosafety, ethical issues, and IPR

Syllabus: **Teaching Hours: 45**

Unit 1: Fundamentals of Plant Tissue Culture: **5 Hours**

History of conventional Plant Breeding and and evolution of Plant Biotechnology; Laboratory organization; Aseptic & Sterilization techniques; Nutrient Media- its composition, formulation selection of suitable media, Phytohormones and regulators. Concept of totipotency and differentiation.

Unit 2: Micropropogation **8 Hours**

Micropropagation- Tissue culture techniques - Callus culture, initiation and maintenance of callus, Direct and Indirect morphogenesis, Somatic embryogenesis and Synthetic seed production; Haploid, Double haploid & Triploid culture; Embryo culture & embryo rescue technique; Homozygous plant production. Protoplast technology assisted crop improvement- Protoplast isolation, culture and fusion; Selection of hybrid cells and regeneration of hybrid plants regeneration of hybrid plants; Symmetric and Asymmetric hybrids, Cybrids, Anther, Pollen and Ovary culture for production of haploid plants and homozygous lines. Somaclonal variation. In vitro mutation – Sexual incompatibility and male sterility. Cryopreservation, DNA banks for germplasm conservation. Applications in genetic modification and somatic hybridization.

Unit 3: Genome Editing in Plants: **8 Hours**

Methods for genome modification – Multiplex genome editing, Large fragment deletions and Chromosome Engineering, Synthetic and Artificial plant chromosomes, Synthtetic Plant Genomes; Use of CRISPER/CAS9/Cpf1/CAS12a for genome modification in plants to produce novel designer crops, Advantages and limitations – Nanobiotechnology for Biosafety of genome edited plants, Precision Agriculture – Iterative Recombinase Technology, Examples of Genome edited plants

Unit 4: Plant Genetic Transformation Technology **10 Hours**

Introduction to genetic transformation, Biological (vector mediated), Physical & Chemical delivery method; Biological - Vectors & its types used in higher plants - Agrobacterium-mediated transformation. Tumor-inducing (Ti) plasmids, Binary and Cointegrate vectors, Physical delivery methods of gene transfer (particle bombardment, microinjection), Chemical mediated DNA delivery - electroporation, liposome, and ultrasonication; Plant Selection markers, Reporter gene marker (GFP, luciferase, GUS), Molecular markers [RFLPs (Restriction Fragment Length Polymorphism), RAPD (Random Amplified Polymorphic DNA), STS (Sequence-Tagged Sites) and EST (Expressed Sequence Tags), microsatellites- SSR (Simple Sequence Repeats), SCAR (sequence characterized amplified regions), SSCP (single strand conformational polymorphism), AFLP (Amplified fragment length polymorphism, SNP (Single Nucleotide Polymorphism)], Transgene silencing and stability, Selection and screening strategies, Analysis of transgenics for expression and characterization.

Unit 5: Micropropagation and Transgenic for Agricultural and Environmental Application **8 Hours**

Resistance to biotic stresses (insect, viral, fungal and bacterial resistance etc.); Herbicide resistance in transgenic plants. Resistance against abiotic stresses (drought, salinity, heavy metal etc.), enhancement of phytoremediation properties in transgenic plants and wasteland utilization. Genetic engineering for enhancing photosynthetic efficiency; Nutrient uptake efficiency improvement; Improvement of seed and fruit quality; Biofortification; Molecular farming. Tissue culture of Dates/Banana/ Ground Nuts and other major horticultural crops.

Unit 6: Plants as Factories **6 Hours**

Bioreactors for plant cell cultures – types, advantages, challenges; Molecular farming concept; Secondary metabolite production; Transgenic plants and recombinant protein - production of glucocerebrosidase and hirudin; Edible vaccines and Plantibodies; Biofuel production; Biopesticides and Pharmaceuticals, Germplasm conservation, relevance to the herbal industry and Future commercial applications of plant tissue culture.

References:

1. Plant biotechnology and genetics: Principles, techniques, and applications (3nd ed.). Stewart, C. N. (Ed.). Wiley-Blackwell (2025).
2. Plant Genetic Engineering and Biotechnology: Zamin Hu, Zan Xiao, Yi Ren, Chengmin Fang (2024)
3. Plant Biotechnology: S.M Paul Khurrana and Narendra Kumar, Scientific Publishers (2022)
4. Introduction to plant biotechnology (3rd ed) Chawla, H. S. Oxford & IBH Publishing (2020).
5. Plant biotechnology: BD Singh, MedTech Science Press. 4th edition (2022).
6. Plant tissue culture, development, and biotechnology. Trigiano, R. N., & Gray, D. J. CRC Press (2016).

7. Pechanova, O., & Kole, C. (Eds.). Transgenic crops V (Biotechnology in Agriculture and Forestry, Vol. 67). Springer (2011).
8. Elements of Biotechnology: P K Gupta, Rastogi and Co. Meerut, (2007).
9. Transgenic crops V. Pechanova, O., & Kole, C. (Eds.) (Biotechnology in Agriculture and Forestry, Vol. 67). Springer. (2011).
10. Plant propagation by tissue culture (3rd ed., Vols. 1 & 2). George, E. F., Hall, M. A., & De Klerk, G. J. Springer (2008).
11. Plant biotechnology: Slater, A., Scott, N. W., & Fowler, M. R. The genetic manipulation of plants (2nd ed.). Oxford University Press (2008).
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13. An Introduction to Plant Tissue Culture: M K Razdan. Tata Mc Graw Hill Publishing Co. Ltd. (2000)
14. Plant Biotechnology, J. Hammond, P. McGarvey and V Yusibov (Eds) Springer Verlag (2000)
15. Plant Cell and Tissue Culture for the Production of Food Ingredients: T-J, Fu, G. Singh, and W R Curtis (Eds.): Kluwer Academic/Plenum Press. (1999)
16. Plant tissue culture: Theory and practice. Bhojwani, S. S., & Razdan, M. K. Elsevier (1996).
17. Plants as Factories for Bioproduction-Recent Developments and Applications, J. Steingroewer, Springer (2024) **SBN-10 :** 303160279X; **ISBN-13 :** 978-3031602795

L	T	P	C
2	-	-	2

Course Code	7SL901CC27
Course Title	Research Methods

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Understand the various kind of research designs and their importance in conducting the research work.

CO2 Propose original research proposal and demonstrate skills for effective communication through its defense

CO3 Application of bio statistical tools for evaluation of statistical relevance of results obtained

Syllabus: **Teaching Hour: 30**

Unit 1: Research **8 Hours**

Definition of Research, Applications of Research and Types, Validity, Literature Review, develop a Theoretical and Conceptual Framework, writing up the Review, Formulating and Research Problem: Sources, Considerations, Definition of Variables, Types, Cooperative vs Collaborative Research; Disruptive vs Developmental Research; Research Modeling: Types of Models, Model Building and Stages, Data Consideration.

Unit 2: Research Design **10 Hours**

Design of Experiments, Objectives, Strategies, Replication, Randomization, Blocking, Guidelines for Design of Experiments, Simple Comparative Experiments- Two Sample T-Test, P-Value, Confidence Intervals, Paired Comparisons, Single Factor Experiment: Analysis of Variance (ANOVA), Randomized Complete Block Design.

Unit 3: Research Proposal **10 Hours**

Contents-Preamble, The Problem, Objectives, Hypothesis, Study Design, Setup, Measurement Procedures, Analysis of Data, Organization of Report; Displaying Data tables, Graphs and Charts, writing a Research Report-Developing an Outline, Key Elements- Objective, Introduction, Design or Rationale of Work, Experimental Methods, Procedures, Measurements, Results, Discussion, Conclusion, Referencing and Various Formats for Reference.

Unit 4: Ethics and Scientific Conduct **7 hours**

Good Laboratory practice (GLP) – Data Documentation, SOP Plagiarism, Scientific conduct and misconduct, Ethical Guidelines, Biosafety; Principles of Human and Animal Research ethics.

References:

1. Central Drugs Standard Control Organization Http://CDSCO.NIC.IN/
2. Http://WWW.Patentoffice.NIC.IN/
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5. Ranjit Kumar, Research Methodology- A Step-By-Step Guide for Beginners, Pearson Education, Delhi. 2006.
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9. Besterfield, Dale H. 3/E, Total Quality Management, Pearson Education, New Delhi, 2005.
10. C. George Thomas, Research Methodology and Scientific Writing, New Delhi, 2015.
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12. Kartikeyan, S. Chaturvedi, R.M and Bhosale, Comprehensive Textbook of Bio-statics and Research Methodology, Mumbai, 2016.

L	T	P	C
-	-	8	4

Course Code	7SL204CC27
Course Title	Laboratory III

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Demonstrate the skill to design controlled experiments for performance of standard practical's to understand the physiology and adaptation of microbial systems in different environments.

CO2 Record and report experimental results in standard format and derive coherent conclusions of results stating their significance.

CO3 Correlate the theoretical concepts to appreciate and evaluate results obtained through scientific enquiry.

Syllabus: **Teaching Hour: 150**

1. Isolation and preparation of hepatocyte, pancreatic cells or lymphocytes for primary cell culture
2. Estimation of live cells using Trypan blue test by hemocytometer and viablity testing
3. Estimation of live cells using PI by flow cytometry
4. Cell line passaging for establishing continuous cell culture
5. To study early and terminal differentiation of mammalian cell using specific marker by immunofluorescence technique
6. To study mammalian gene transfection in CHO/HEK 239 cells in vitro
7. Enumeration of free living nitrogen fixing population in soil by most probable number (MPN) method
8. Estimation of the most probable number (MPN) of sulfate reducing bacteria in soil samples
9. Estimating Soil microbial activity through soil respiration
10. Estimating soil microbial activity by dehydrogenase enzyme
11. Estimation of BOD
12. Testing for microbiological quality (Coli-form test) for potable water
13. Physico-chemical characterization of waste water; Perform protein purification by size exclusion chromatography and HPLC
14. Screening of antibiotic resistant genes in bacteria
15. Study of Bacteriocin producing Lactic Acid Bacteria (LAB): Isolation, identification and partial purification
16. Study on the dark repair mechanism of *E. coli* and its effect on antibiotic resistance pattern.

References:

1. Doyle, Alan. Cell and tissue culture: laboratory procedures in biotechnology. John Wiley & Sons Ltd, 1998.
2. Freshney, R. Ian. "Basic principles of cell culture." Culture of cells for tissue engineering (2006): 3-22.
3. Freshney, R. Ian. Culture of animal cells: a manual of basic technique and specialized applications. 7th ed., John Wiley & Sons, 2016.
4. Tortora, Gerard J., and Bryan H. Derrickson. Principles of anatomy and physiology. 13th ed. John Wiley & Sons, 2011.
5. McMaster, Marvin C., and A. HPLC. A Practical User's Guide. 2nd ed. Wiley-Vch, 2007.
6. Prajapati, Bhumika, et al. "Divergent outcomes of gut microbiota alteration upon use of spectrum antibiotics in high sugar diet-induced diabetes in rats." RSC advances 8.46 (2018): 26201-26211.

Elective Courses II

L	T	P	C
3	-	-	3

Course Code	7SL401ME27
Course Title	Agriculture & Environmental Microbiology

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Describe role of microorganism in recycling soil nutrients, biodegradation of complex plant polymers, sustaining and improving plant growth through improving nutrient availability, production of plant growth promoting substances and inhibiting pathogens

CO2 Critically discuss the need for environmental microbiology and agricultural microbiology and explain their limitations

CO3 Clarify application of microorganisms in varied fields of agricultural and environmental microbiology like bioremediation, biofertilizers and waste water treatment

CO4 Analyse various aspects of N_2 fixation, P solubilization, PGPR, biodegradation and bioremediation mechanisms provided by microbes

Syllabus: **Teaching hours:45**

Unit 1: Biological Nitrogen fixation 10 Hours
Physiology and Biochemistry of Nitrogen fixing organisms, Genetics and regulation of nif gene expression, Signalling factors and molecular interaction in establishing Rhizobia legume symbiosis

Unit 2: Phosphate Biofertilizers 6 Hours
PSMs, Inorganic phosphate solubilization and its mechanisms, Phosphate mineralizers – phytate and organic phosphate hydrolyzing bacteria, and Ecto- and Endo- Mycorrhizae

Unit 3: Plant Growth Promoting Rhizobacteria 6 Hours
PGPR in improving plant growth, Mechanism in plant growth promotion, Factors affecting rhizosphere colonization.

Unit 4: Environmental Problems and Monitoring 8 Hours
Pollution and its classification, Effluent standards: examination of waste water characteristics, municipal and industrial waste water, Global environmental problems: global warming, acid rain, ozone depletion, Sampling and analysis, Environmental monitoring and audit, Environmental laws, and policies in India.

Unit 5: Bio-Treatment Kinetics and Reactor Design 8 Hours
Principals of biological treatments, Biological treatments: Composting, Suspended growth systems, Attached growth systems, Bioreactor design: Activated Sludge Process, Tickling Filters, Fluidized bed and Packed bed reactor, Rotating Biological Contractors, Oxidation Ponds and Ditches, Lagoons, Anaerobic Reactors.

Unit 6: Bioremediation and Biodegradation 7 Hours
Bioremediation principles and Processes: Biosorption, Bioaccumulation, Bioconversion, Biotransformation, Bioleaching, Biodegradation, Detoxification, Activation, Acclimatisation and Co-metabolism, strategies and techniques of bioremediation: in situ and ex situ, of Hydrocarbons, Pesticides and Dyes, GMO's in bioremediation and biodegradation.

References:

1. Alexander, M. Biodegradation and Bioremediation, Academic Press, 1994.
2. Arceivala, S.J. and Asolekar, S.R., Wastewater treatment for Pollution Control and Reuse, 3rd edition, Tata McGraw Hill, 2007.
3. Atlas, R.M. and Bartha, R. Microbial Ecology, 4th edition, Pearson Education, 2009.
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11. Paul and Clerk, Soil Microbiology and Biochemistry, 2007.
12. Paul, E.A. (Ed.). Soil Microbiology, Ecology and Biochemistry, 3rd edition, Academic Press, 2007.
13. Pepper, I.L. and Gerba, C.P. Environmental Microbiology – A Laboratory Manual, 2nd edition, Elsevier Academic Press, 2005.
14. Rao, N. S. Subba, Soil Microbiology, 4th edition, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 2008.
15. Thakur, I.S. Environmental Biotechnology – Basic concepts and Applications, I.K. International, 2006.
16. Varma A., Oelmuller R. Advanced Techniques in Soil Microbiology, Springer (India) Pvt. Ltd, 2007.

L	T	P	C
3	-	-	3

Course Code	7SL409ME27
Course Title	Microbiome Health and Disease

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

CO1 Understand the interaction between diet, the microbiome, and the host
CO2 Analyze the role of these interactions in host health and disease
CO3 Evaluate the acquired information to solve research questions and analyze case studies related to the topic
CO4 Development of novel therapeutics via manipulation of microbiome.

Syllabus: **Teaching Hours:45**

Unit 1: Introduction to Microbiome **8 Hours**

Definition and components of the microbiome (bacteria, viruses, fungi, etc.); Microbial diversity and its importance in human health, Milestones in microbiome research; Methodologies in Studying the Microbiome; Challenges and advancements in microbiome analysis.

Unit 2: Microbiome and Human Health **7 Hours**

Human Microbiome and Nutrition; role in Skin, Digestive system, Respiratory system, Urinary system, Reproductive system; Role during pregnancy; Gut-brain axis; Psych biotics

Unit 3: Factors Influencing the Microbiome **8 Hours**

Influence of diet composition, dietary patterns, and food habits on the microbiome; Effects of exercise, stress, sleep, and other lifestyle factors on microbial diversity; Impact of environmental factors; Medical interventions.

Unit 4: Microbiome Dysbiosis and Disease **8 Hours**

Disruptions in Microbial Balance; Alterations in microbiome composition and function; Dysbiosis-associated conditions; Infectious Diseases and Microbiome; Cancer and Chronic Diseases and Microbiome; Dysbiosis and Immune response.

Unit 5: Microbiome, Mycobiome and Virome interaction **7 Hours**

Human Virome and host interaction; Microbiome – Mycobiome interaction; Microbiome – Virome Interaction, Bacteriome-Mycobiome-Virome interaction

Unit 6: Therapeutic Interventions and Applications **7 Hours**

Probiotics, prebiotics, Postbiotics and their mechanisms of action in promoting a healthy microbiome; Sporulating and anaerobic microbes as potential probiotics; Clinical applications; Phage Therapy; Exploration of novel therapeutic avenues, including microbial-based drugs and engineered microbiota; Ethical considerations, regulatory challenges.

References:

1. Almand, E.A., Moore, M.D. and Jaykus, L.-A. (2017) 'Virus-Bacteria Interactions: An Emerging Topic in Human Infection', Viruses, 9(3), p. 58. Available at: https://doi.org/10.3390/v9030058.
2. Douglas, A.E. (2018) Fundamentals of Microbiome Science. Princeton University Press. https://doi.org/10.1515/9781400889822.
3. Handley, S.A. (2016) 'The virome: A missing component of biological interaction networks in health and disease', Genome Medicine, 8(1). Available at: https://doi.org/10.1186/s13073-016-0287-y.
4. Microbiome, Immunity, Digestive Health and Nutrition (2022). Elsevier. https://doi.org/10.1016/C2019-0-04103-9.
5. Microbiome Therapeutics (2023). Elsevier. Available at: https://doi.org/10.1016/C2021-0-01533-9.
6. Parks, D. (no date) Microbiomes: Health and the Environment MAVS OPEN PRESS ARLINGTON.
7. Santus, W., Devlin, J.R. and Behnsen, J. (2021) 'Crossing Kingdoms: How the Mycobiota and Fungal-Bacterial Interactions Impact Host Health and Disease', Infection and Immunity, 89(4). https://doi.org/10.1128/IAI.00648-20.
8. Genevieve Dable-Tupas, Rohini Karunakaran, Peter Paul C Lim, Maria Catherine B Otero. Human Microbiome Drug Targets Modern Approaches in Disease Management, 2024; ISBN: 9780443154355

L	T	P	C
3	-	-	3

Course Code	7SL215ME27
Course Title	Structural Biology and Drug Discovery

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

- CO1 Understand the architecture and building blocks of proteins, evaluate protein folds
- CO2 Understand the protein folding and misfolding and the thermodynamic concepts of protein
- CO3 Apply structure to function
- CO4 **Analyse the structure and function of membranes**
- CO5 Evaluate the macromolecular complexes and their biological complexity

Syllabus: **Teaching Hours:45**

Unit 1: Introduction **7 hours**

Overview of structural biology - Levels of structures in biological macromolecules; non-covalent forces determining biopolymer structure, principals of minimization of conformational energy.

Unit 2: Protein Structure **8 hours**

Proteins primary, secondary and tertiary structures - Structural implications of the peptide bond; Ramachandran Plot; Structural classification of proteins, structural motifs, profiles and protein families; Methods

and techniques for study of protein structure and its perturbations by using X pray crystallography, electron microscopy, NMR techniques, Atomic force microscopy and cryo-EM.

Unit 3: Protein Folding **7 hours**

Folding in vivo and in vitro; protein stability, thermodynamics, and kinetics; Effect of various factors on folding; Folding intermediates- kinetic, equilibrium and molten globule intermediates; Techniques for studying the structure and folding of proteins; chaperones, peptidyl prolyl isomerase (PPI), Protein disulfide isomerase (PDI); Comparison of the structure and stability of proteins of mesophilic and extremophilic origin.

Unit 4: Biomolecular Interactions **7 hours**

Molecular recognition, supramolecular interactions, Protein-protein interactions, and their importance. Protein structure, protein crosslinking and oligomerization and its relevance in disease; Therapeutic approaches.

Unit 5: Techniques that detect protein-nucleic acid interaction **8 hours**

Structural elements of DNA and RNA; nucleic acid-protein complexes and the functional importance of protein-nucleic acid interactions; Protein-micromolecular interaction Therapeutic approaches that target structural elements of protein-nucleic acid interaction relevant to cellular pathophysiology

Unit 6: Membrane Structure **8 hours**

Lipid structure and their organization; Comparison between different membrane models; carrier transport, ion transport, active and passive transport, ion pumps, water transport, use of liposomes for membrane models and drug delivery systems. Drug treatment strategy that targets various membrane transport relevant to different kind of diseases.

References:

1. Central Drugs Standard Control Organization Http://CDSCO.NIC.IN/
2. Http://WWW.Patentoffice.NIC.IN/
3. WWW.OECD.ORG/DATAOECD/9/11/33663321.PDF
4. Http://WWW.FDA.GOV/FDAC/Special/Testtubetopatient/Studies. Html
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6. Trochim, William M.K., 2/E, Research Methods, Biztantra, Dreamtech Press, New Delhi, 2003.
7. Montgomery, Douglas C. 5/E, Design and Analysis of Experiments, Wiley India, 2007.
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11. Science communication: A practical Gui
12. de for scientists, Laura Bowater, Kay Yeoman, ISBN: 978-1-118-40666-3 October 2012 Wiley-Blackwell 384 Pages;
13. https://www.wiley.com/en-us/Science+Communication%3A+A+Practical+Guide+for+Scientists-p-9781118406663
14. Structural Biology and drug discovery, method techniques and practices edited by Jean Paul Renaud, Wiley March 2020.
15. Structure based drug discovery, https://link.springer.com/book/10.1007/978-1-61779-520-6

Elective Courses III

L	T	P	C
3	-	-	3

Course Code	7SL216ME27
Course Title	Molecular Medicine

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

- CO1 Understand the basics introduction of molecular medicine
- CO2 Analysis of the disease specific pathological mechanism and target for medicinal approach
- CO3 Apply the methods to characterize therapeutic effects of medicine
- CO4 **Validating the molecular diagnosis of the disease**

Syllabus: **Teaching Hours:45**

Unit 1: Introduction to Molecular Medicine **7 hours**

Fundamental aspects of molecular medicine genetic mutation and repair. single nucleotide polymorphism of gene and biological consequences. General strategy and Fundamental aspects of infectious vs non-infectious diseases and acute and chronic disease progression. Role of biological environmental impact in various major diseases.

Unit 2: **Cell signaling events and small molecule blocker** **7 hours**

Introduction of intracellular and extracellular signaling pathway. Role of Receptors and adaptor protein in cell signaling. Role of genetic mutation and mutant protein in cell signaling defect and associated diseases. Design of small molecule inhibitors and other strategies to counter balance the genetic and protein mutation restoring cellular physiology.

Unit 3: Pathophysiological spectrum of various diseases **8 hours**

Discussing various factors including genetic, SNPS, protein mutation, cell signaling and endothelial disfunction etc. for the trigger of cancer, diabetes, neurodegeneration, coronary artery disease and others.

Unit 4: Effect of medicine in biological system **6 hours**

Basic ideas on biodistribution and pharmacokinetic of medicine, toxicity and hepatic metabolism of the oral medicine, various types of formulation of the medicine, biotechnology drugs such as antibody, protein and other forms of drug conjugate used as formulation for drug delivery

Unit 5: Molecular Diagnosis **8 hours**

Brief description for application of to various analytical tools to characterize the drug like molecules. Use of laboratory-based cell biological markers, prognostic marker for the validation of drug effect on biological molecule such as DNA sequencing analysis, mutation analysis, PCR, gene therapy, Si-RNA knockdown, western blot, cell viability assay etc.

Unit 6: **Drug Design and Computational Drug Discovery Approach** **9 hours**

Rational drug design to targets that is relevant to various diseases such as cancer, diabetes, neuronal disorders, psychological complications, osteoporosis, endocrine disorders, and others etc. Structure activity relationship. Application of bio-informatics method and in silico application to drug design and virtual screening of drug against a disease specific target gene/protein.

References:

1. Alberts B, Johnson A, Lewis J, Raff M, Roberts K and Walter P, "Molecular Biology of the Cell", Fifth Edition, Garland Publishing Inc. 2008.
2. Molecular Medicine Book by Robert M. White (Author), David W. Brown (Author), Steven A. Williams. ISBN-10, 1594250332.
3. Introduction to Molecular Medicine by D. W. Ross, publisher Springer, 9th march 2013.
4. Molecular Medicine is the application of genetic or DNA-based knowledge to the modern practice of medicine. *Molecular Medicine* by R J Trent, 22nd August 2022.
5. *Philosophy of Molecular Medicine: Foundational Issues in Theory and Practice* aims at a systematic investigation of a number of foundational issues in the field of molecular medicine. Routledge publication, 1st edition (18 Dec. 2020).
6. Textbook Of Biochemistry, Biotechnology, Allied And Molecular Medicine by Gp Talwar, Seyed E Hasnain , 4th edition. November 2015 publication.

L	T	P	C
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Course Code	7SL202ME27
Course Title	Cancer Biology

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Describe and appraise the fundamentals of cellular processes involving molecular genetic basis of multistep process of carcinogenesis Illustrate mechanisms of physical, biological, and chemical cancer-causing agents as well as spontaneous cancer onset in terms of role of oncogenes and tumour suppressor genes, deregulation of cell cycle and differentiation in cancer cells.

CO2 Articulate host-environment interactions including susceptibility factors in cancer predisposition; cancer classification systems; principles of cancer diagnosis, prognosis, and response to therapy and management in the laboratory.

CO3 Demonstrate understanding of cancer control for disease-free, relapse-free, and metastasis-free longer survival using knowledge of molecular players and factors governing cancer spread from primary sites, metastasis cascade, and invasion.

Syllabus: **Teaching Hours: 45**

Unit 1: Introduction to Cancer Biology **6 Hours**

History of cancer and various theories of Cancer etiology, Warning signs of cancer; Types of cancer; cancer classification systems: Epidemiology; Updates in hallmarks of cancer cells including; Self-sufficiency in growth signals, insensitivity to growth suppressive signals, evading programmed cell death, replicative immortality, sustained angiogenesis, invasion and metastasis, reprogramming energy metabolism, evading immune destruction, tumor promoting inflammation, genomic instability, and others

Unit 2: Molecular Cell Biology of Cancer 8 Hours

Proto-oncogenes and Oncogenes, Mechanisms of inactivation of proto-oncogenes and affected cellular pathways; Tumor suppressor genes, two-hit theory, mi-RNA and other regulators of cellular pathways and cancer, modulation of growth factors, receptors, signal transduction, Cancer Stem cells, Biology, and implications; Apoptosis, Autophagy, Necroptosis, Ferroptosis and pyroptosis.

Unit 3: Cancer Genetics, Cytogenetics and Genomics: 10 Hours

Constitutional and Acquired Genetic Determinants of Cancer; Genetic Predisposition to Cancer; Hereditary cancer syndromes and Familial Cancers; Molecular pathogenesis of acquired chromosomal aberrations, fusion genes, Common techniques for analysis of alterations in chromosomes and DNA, Techniques for analysis of alterations in chromosomes and DNA.

Unit 4: Principles of Carcinogenesis 8 Hours

Physical, Chemical and Biological Carcinogenesis, Genotoxic and non-genotoxic carcinogens, Cancer Metabolism and Targets of Carcinogenesis, Molecular mechanism of Carcinogenesis. Cancer risk factors and differential susceptibility, IARC and WHO and OECD guidelines.

Unit 5: Cancer Metastasis 8 Hours

Metastatic cascade; Basement Membrane disruption; Three-step theory of Invasion; Heterogeneity of metastatic phenotype; Epidermal Mesenchymal Transition, Molecular signatures and organ preference in metastasis and Angiogenesis

Unit 6: Cancer Biomarkers and Therapeutics 5 Hours

Classical and novel strategies for cancer treatment; Tumor markers for cancer diagnosis, prognosis, and therapy decisions; Cancer Immunology and therapeutic interventions, Humanized /Chimeric antibodies in cancer diagnosis and treatment, Targeted drug delivery and drug delivery systems, Animal models for cancer, Cancer vaccine, Clinical trials, Immune cell therapies, Gene Therapy, survival and response monitoring, targeted therapy with examples of clinical importance, personalized medicine

References:

1. Weinberg R., Biology of Cancer, Garland Science, June, 2010
2. D. Liebler, Proteomics in cancer research, 2004
3. David M. Terrian, Cancer cell signalling, Methods, and protocols, Volum 218 (Methods in Molecular Biology), 2003.
4. Strachan Tom and Read Andrew P. (2010) Human Molecular Genetics, 4th Edition, Garland Science (Taylor and Francis Group), London and New York
5. K.L. Rudolph, Telomeres and Telomerase in ageing, disease, and cancer, 2008.
6. Maly B.W.J., Virology: A practical approach, IRL Press, Oxford, 1987.
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8. Knowles, M.A., Selby P., An Introduction to the Cellular and Molecular Biology of Cancer, Oxford Medical publications, 2005.
9. Vincent, T. De Vita, Lawrence T. S., Rosenberg, S. A., Cancer: Principles & Practice of Oncology, 10th Edition, Lippincot, 2011
10. http://atlasgeneticsoncology.org
11. http://cgap.nci.nih.gov/Chromosomes/Mitelman
12. http://www.humanvariomeproject.org
13. https://www.genome.gov/hapmap

L	T	P	C
3	-	-	3

Course Code	7SL411ME27
Course Title	Food and Dairy Microbiology

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

- CO1 Learn fundamentals associated with microbiology of dairy and non-dairy foods
- CO2 Learn principles of food preservation
- CO3 Learn role of microbes in food spoilage, and risks imposed by food-borne pathogens

Syllabus: **Teaching hours: 45**

Unit 1: The Scope of Food Microbiology 7 Hours

Microorganisms in foods; Microbial growth response in the food environment; Intrinsic and extrinsic factors affecting growth and survival of microorganisms in foods

Unit 2: Microbiology of Food Preservation 8 Hours

Heat processing; Irradiation; Ultrasonication; High-pressure processing; Low-temperature storage; Chemical preservatives; Modification of atmosphere; Control of water activity

Unit 3: Dairy Microbiology 7 Hours

Milk and milk processing; Microbiology of raw milk and market milk; Fermented milks; Therapeutic milks; Microbiology of fermented milk products

Unit 4: Microbes as process organisms in fermentation industry 7 Hours

Starter cultures; Probiotics, prebiotics, synbiotics, postbiotics, and parabiotics; Production and delivery of probiotics; Nutraceuticals of microbial origin

Unit 5: Food Microbiology and Public Health **8 Hours**

Microbial food spoilage; Bacterial and non-bacterial agents of foodborne illness; Detection of pathogens in food samples

Unit 6: Quality Control in Food and Dairy Industry **8 Hours**

Quality Control in Food and Dairy Industry: The Hazard Analysis and Critical Control Point (HACCP) Concept; Relevant FSSAI and The Codex Alimentarius Commission (CAC) regulations; Hygiene in food/milk product manufacture

References:

1 Adams and Moss (2007). Food Microbiology. New Age International Publishers
2 Richard Robinson (Ed) (2002). Dairy Microbiology Handbook: The Microbiology of Milk and Milk Products, 3rd Edition. Wiley. ISBN: 978-0-471-38596-7
3 Ralph Early (1997) (Ed). The Technology of Dairy Products. Springer. ISBN: 978-0-7514-0344-2.
4 Bibek Ray and Arun Bhunia (2025). Fundamental Food Microbiology. Sixth Edition. CRC Press.
5 MP Doyle, Diez-Gonalez, and Colin Hill (2019). Food Microbiology: Fundamentals and Frontiers. Fifth edition. ASM Press.

SEMESTER IV

Elective Course

L	T	P	C
-	-	-	15

Course Code	7SL902ME27
Course Title	Dissertation

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Develop understanding in the field of scientific research at the academic as well as industrial sector. This will students to identify scientific problems and design proposals to address and implement ideas. This enables them to communicate the same to a greater audience.

This will benefit the students to perform well in their job interviews and to design their CV which can evoke

ANNEXURE-I

M.Sc. Microbiology

Nirma University
Institute of Science
M Sc. in Microbiology
Teaching & Examination Scheme

M. Sc. SEMESTER-I

w.e.f.: Academic Year 2026-27

Course Code	Course Title	Teaching Scheme (hours/week)						Examination Scheme			
		L	T	P	OLA	TH	C	Duration (hrs)	Component Weightage		
								SEE	CE	LPW	SEE
6SL105CC26	Cell and Molecular Biology	60	-	-	60	120	4	3	0.5	-	0.5
6SL305CC26	Immunology	60	-	-	60	120	4	3	0.5	-	0.5
6SL202CC26	Human Physiology	45	-	-	45	90	3	3	0.5	-	0.5
6SL402CC26	Microbiology	45	-	-	45	90	3	3	0.5	-	0.5
6SL203CC26	Metabolism	45	-	-	45	90	3	3	0.5	-	0.5
6SL102CC26	Laboratory I	-	-	150	-	150	5	-	1.00	-	-
6SL801CC26	Scientific Communications - I	15	-	-	15	30	1	-	1.0	-	-
	Total					**690**	**23**				

M. Sc. SEMESTER-II

w.e.f.: Academic Year 2026-27

Course Code	Course Title	Teaching Scheme (hours/week)						Examination Scheme			
		L	T	P	OLA	TH	C	Duration (hrs)	Component Weightage		
								SEE	CE	LPW	SEE
6SL403CC26	Industrial Microbiology & Fermentation Technology	45	-	-	45	90	3	3	0.5	-	0.5
6SL104CC26	Bioanalytical Techniques	45	-	-	45	90	3	3	0.5	-	0.5
6SL303CC26	Genetic Engineering	45	-	-	45	90	3	3	0.5	-	0.5
6SL404CC26	Microbial Genetics	45	-	-	45	90	3	3	0.5	-	0.5
6SL205CC26	Laboratory II	-	-	150	-	150	5	-	1.00	-	-
6SL802CC26	Scientific Communications - II	15	-	-	15	30	1	-	1.0	-	-
	Elective I	45	-	-	45	90	3	3	0.5	-	0.5
	Total					**630**	**21**				

Activities under Other Learning Activities
Class test; Sessional Test; Semester End Examination; Assignment; Individual/Group presentations; Expert lectures; Guest lectures; Other Academic activities

M. Sc. SEMESTER-III

w.e.f.: Academic Year 2026-27

Course Code	Course Title	Teaching Scheme (hours/week)						Examination Scheme			
		L	T	P	OLA	TH	C	Duration (hrs)	Component Weightage		
								SEE	CE	LPW	SEE
7SL405CC27	Molecular Microbial Physiology	45	-	-	45	90	3	3	0.5	-	0.5
7SL302CC27	Genomics & Proteomics	45	-	-	45	90	3	3	0.5	-	0.5
7SL410CC27	Medical Microbiology	45	-	-	45	90	3	3	0.5	-	0.5
7SL901CC27	Research Methods	30	-	-	30	60	2	-	1.00	-	-
7SL204CC27	Laboratory III	-	-	120	-	120	4	-	1.00	-	-
	Elective II	45	-	-	45	90	3	3	0.5	-	0.5
	Elective III	45	-	-	45	90	3	3	0.5	-	0.5
	Total					**630**	**21**				

M. Sc. SEMESTER-IV

w.e.f.: Academic Year 2026-27

Course Code	Course Title	Teaching Scheme (hours/week)						Examination Scheme			
		L	T	P	OLA	TH	C	Duration (hrs)	Component Weightage		
								SEE	CE	LPW	SEE
7SL902ME27	Dissertation	-	-	450	-	450	15	3	0.5	-	0.5
7SL903ME27	Internship	-	-	450	-	450	15	3	0.5	-	0.5
	Total					**450**	**15**				

Elective I (*Semester II*)

6SL106ME26	Nanobiotechnology
7SL304ME26	Vaccinology
6SL405ME26	Microbial Ecology

Elective II (*Semester III*)

7SL401ME27	Agriculture & Environmental Microbiology
7SL409ME27	Microbiome in Health and Disease
7SL215ME27	Structural Biology and Drug Discovery

Elective III (*Semester III*)

7SL216ME27	Molecular Medicine
7SL202ME27	Cancer Biology
7SL411ME27	Food and Dairy Microbiology

Activities under Other Learning Activities

Class test; Sessional Test; Semester End Examination; Assignment; Individual/Group presentations; Expert lectures; Guest lectures; Other Academic activities

SEMESTER I

Core Courses

L	T	P	C
4	-	-	4

Course Code	**6SL105CC26**
Course Title	**Cell & Molecular Biology**

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Understand and appraise the fundamentals of cell as a unit of living organisms and their organelles in terms of structure and functions.

CO2 Evaluate the cellular mechanisms of cell-cell interactions, cell communications, cell signalling pathways, molecular mechanisms and their crosstalk, cell division, cell death, and regulation Analyse the concept of central dogma and its updates

CO3 Demonstrate understanding of molecular processes and principles of DNA replication, transcription, translation, and regulation

Syllabus: **Teaching hours**: **60 Hours**

Unit 1: Plasma membranes; transport, Cell–Cell Adhesion and Communication **7 Hours**

Plasma membrane transport, structure & molecular composition of various transporters for active and passive transport, Cell-cell adhesions: Ca++ dependent and Ca++ independent; Extracellular matrix.

Unit 2: Cytoskeleton; intracellular protein traffic **8 Hours**

Actin, Intermediate Filaments and Microtubules; Structure, Dynamics, and functions of each in mitosis, cell movement; motor proteins and accessory proteins; Gated, Nuclear, and Vesicular protein traffic intracellular environment.

Unit 3: Cell Signaling **8 Hours**

Cell Surface Receptors; Signaling from Plasma Membrane to Nucleus, Map Kinase Pathways, G-protein coupled receptors, signal transduction pathways, second messengers, regulation of signaling pathways, neurotransmission, and regulation

Unit 4: Cell Cycle **7 Hours**

Mitosis, Meiosis, Cell Cycle, Role of Cyclins and Cyclin Dependent Kinases, Regulation of Cdk –Cyclin Activity, Cell cycle check-points; necrosis, senescence, and apoptosis

Unit 5: DNA structure and Genome organization **7 Hours**

DNA structure and function: Central dogma, DNA as genetic material, DNA supercoiling, gyrases, topoisomerases; Physical properties of nucleic acids: Chromatin structure; Chromatin remodeling and its functional significance.

Unit 6: DNA Replication, repair, and recombination **8 Hours**

Mechanism of Prokaryotic and Eukaryotic DNA replication; DNA damaging agents; DNA repair - Components and pathways; DNA recombination Components and pathways.

Unit 7: Transcription **8 Hours**

Structure and function of mRNA; Mechanism of transcription in prokaryotes and eukaryotes; RNA processing: splicing, capping, polyadenylation, and base modifications; Prokaryotic gene regulation: Lac operon, Attenuation, antitermination, small RNAs, riboswitch.

Unit 8: Translation **7 Hours**

Structure and function of mRNA, rRNA, and tRNA; Genetic code; Ribosomes; Mechanism of translation in prokaryotic and eukaryotes; inhibitors of translational; post-translational modifications.

References:

1. Alberts, Bruce, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts and Peter Walter. Molecular Biology of the Cell. 7th Ed. New York: Garland Science, Taylor and Francis Group, LLC, 2022.
2. Gerald K., Cell and Molecular Biology, Concept and Experiment, 6th Edition, Wiley, 2013.
3. Kleinsmith, L. J. J. Principles of Cell and Molecular Biology, 2nd Edition, Benjamin Cummings, 1997.
4. Krebs, J. E., Lewin, B., Goldstein, E. S., & Kilpatrick, S. T. (2014). Genes, XI.
5. Lodish, H., Berk A., Kaiser C. A., Krieger M., Scott M.P., Bretscher A., Ploegh H., and Matsudaira P., Molecular Cell Biology, 6th Edition, Freeman, W. H. and Co., 2008.
6. Pollard, T. D., and Earnshaw, W. C., Cell Biology 4th Edition, Saunders Elsevier, 2023.
7. Stryer, L., Bery, J. M., Dymoczko, J. L., Biochemistry. 10th Edition, WH Freeman and Co. New York, 2023.
8. Watson, J. D., & Levinthal, C. (2014). Molecular biology of the gene, 7th Edition.

L	T	P	C
4	-	-	4

Course Code	**6SL305CC26**
Course Title	**Immunology**

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

CO1 Develop good understanding on how immune system discriminate self-from non-self.
CO2 Evaluate the immune response of the host encountering the pathogen or upon vaccination.
CO3 Understand how MHCs play critical role in shaping specific adaptive immune responses
CO1 Select target antigen or immunogen against which immune response is generated
CO2 Develop strategies to regulate immune response against the self
CO3 Design immunoassays based on the monoclonal antibodies

Syllabus: **Teaching Hours: 60**

Unit 1: Introduction **6 Hours**
Cells of the immune system, Hematopoiesis, structure and function of primary and secondary lymphoid organs, Innate immune system, PAMPs (pathogen associated molecular patterns), DAMPs (damage associated molecular patterns), PRRs (pattern recognition receptors), Antigen (immunogen, haptens and carrier).

Unit 2: Antibody and Complement **8 Hours**
Structure and functions of immunoglobulins, Isotypic, allotypic and Idiotypic variations; Complement activation and regulation.

Unit 3: Generation of Diversity **8 Hours**
Generation of antigen receptor diversity (VJ/VDJ recombination for BCR and TCR), somatic hypermutations, affinity maturation, B and T cell Development.

Unit 4: MHC and APP (antigen processing and presentation) **8 Hours**
Polymorphism of MHC genes, Role of MHC antigens in immune responses, MHC antigens in transplantation; Antigen-uptake, processing, presentation/cross-presentation.

Unit 5: Lymphocyte activation and trafficking **8 Hours**
B and T cell activation including signaling, differentiation, memory formation and recall, lymphocyte trafficking and immune surveillance

Unit 6: Cytokines **6 Hours**
Interleukins, monokines, transforming growth factors, chemokines, their receptors, signaling and functions.

Unit 7: Tolerance **8 Hours**
Autoimmunity, transplantation, allergy and hypersensitivity, cancer immunity, immune-deficiency.

Unit 8: Immuno-technology **8 Hours**
Immunodiffusion assay (radial diffusion, Ouchterlony double diffusion), RIA (radio immune assay), ELISA, Immune-PCR, Immunoblot, Immunocytochemistry, Immunoprecipitation, B cell and T cell hybridoma technology, Flow-cytometry, Single chain antibodies, CAR-T cell, CAR-N

References:

1. Janeway, C (2018) Janeway's immunobiology. Garland Science 11th Edition.
2. Kindt, T. J (2018). Kuby immunology. Macmillan. 8th Edition
3. Paul, W. E. (2012). Fundamental immunology. Lipincott & Wilkins, 8th Edition
4. Abbas, A. K., Lichtman, A. H., & Pillai, Shiva. (2017). Cellular and molecular immunology WB Saunders Co. Philadelphia, Pennsylvania, 186-204, 9th Edition
5. Coico, R. (2015). Immunology: A Short course. John Wiley & Sons, 7th edition
6. Peter J. Delves, Seamus J. Martin, Dennis R. Burton, and Ivan M. Roitt. (2017). Roitt's essential immunology John Wiley & Sons. 13th Edition.

L	T	P	C
3	-	-	3

Course Code	**6SL202CC26**
Course Title	**Human Physiology**

Course Learning Outcomes (CLO):
At the end of the course, students will be able to

CO1 To identify basic organisation of biological system of the human body and define their role.
CO2 To describe and relate the structure to functional role of each organ and organ system
CO3 To comprehend interactions amongst various organs within/between system/s, their negative and positive feedback to maintain steady state and equilibrium in the body.
CO4 To discuss, interpret and analyze biochemical alterations and evaluate the pathophysiological changes during diseased condition.

Syllabus: **Teaching hours**: **45**

Unit 1: Digestive System **9 Hours**
Digestive Processes; Structural organisation and functions of Alimentary Canal (GI tract); Structure and functions of salivary gland, teeth, pancreas, liver;

Physiology of digestion and absorption. Diseases/Disorders of digestive system.

Unit 2: Cardiovascular System 9 Hours
Structure and functions of blood — formed elements (blood cells) and plasma, physiology of blood coagulation. Grouping of blood; Basic structure of heart, conduction system and cardiac cycle; Organisational structure of blood vessels and lymphatic vessels. Diseases/Disorders of CVS.

Unit 3: Respiratory System 6 Hours
Structural Organisation of Respiratory System: Structure and functions of nose, larynx, trachea, bronchi, and lungs; Physiology of Respiration (inspiration, expiration, pulmonary air volumes and capacities), Transportation of respiratory gases. Diseases/Diseases of Respiratory System.

Unit 4: Urinary System 9 Hours
Anatomical Structure of functional unit of kidney (Nephron); Blood and nerve supply of kidney; Physiology of urine formation (glomerular filtration, tabular re-absorption, tabular secretion); characteristics of urine and its utility in measuring health states; Homeostasis. Diseases/Diseases of Urinary System.

Unit 5: Skeletal System 6 Hours
Structural Organisation of Skeletal System — Axial and appendicular system; structure and types of bones; Articulations - fibrous, cartilaginous, and synovial joints; Types of Synovial joints (gliding, hinge, pivot, ellipsoidal, saddle and ball and socket joints). Diseases/Disorders of Skeletal System.

Unit 6: Muscular System 6 Hours
Types, characteristic and functions of muscles (skeletal, smooth, and cardiac muscles); neuro muscular junctions; homeostasis and muscles (oxygen debt, muscle fatigue and heat production). Diseases/Disorders of Muscular System.

References:

1. Guyton, H., Textbook of Medical Physiology, Elsevier, 2000.
2. Tortora, G. J. and Derrickson, B. H., Principles of Anatomy and Physiology, Wiley and Sons, 2009
3. Gilbert, S. E., Developmental Biology, Sinauer Associates, 6th Edition, 2010.
4. Holes Human Anatomy and Physiology by David Shier, Jackie Butler, Ricki Lewis. McGraw hill Education 2015, 8th ed.
5. Essential of Human Physiology for Pharmacy by McCorry, Laurie Kelly, Boca Raton CRC Press 2008
6. Basic Anatomy: General Anatomy and Upper limg by Oommen Anitha, New Delhi Ane Books Pvt. Ltd. 2010
7. Anatomy & Physiology by Gerard Tortora J,Derrickson, Bryan., Delhi Wiley India (P) Ltd. 2014.
8. Anatomy & Physiology; workbook by Gerard Tortora J,Derrickson, Bryan., Delhi Wiley India (P) Ltd. 2014.

L	T	P	C
3	-	-	3

Course Code	**6SL402CC26**
Course Title	**Microbiology**

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

CLO1 Get aquainted with the basic concepts of various fields of Microbiology, and also learn about growth pattern of microbes in different ecosystems.

CLO2 Acquire experimental knowhow of essential microbiological techniques e.g. microscopy, cultivation of microbes, etc.

CLO3 Develop an understanding of various facets of microbes and their applications eg. medical microbiology, industrial microbiology, agricultural microbiology, etc.

Syllabus: Teaching Hours: 45

Unit 1: Foundation in Microbiology 7 Hours
A brief history of microbiology; Origin of life; Prokaryotic and Archaeal cell structures, Microbes in our lives

Unit 2: Microbial Diversity 8 Hours
Archaea, Bacteria, Fungi, Algae, Protozoa, and Viruses

Unit 3. Microbiological Techniques 7 Hours
Bacterial cell cycle, Methods for studying and culturing microbes; Theory and measurement of bacterial growth; Environmental factors affecting growth, Culture preservation and Culture collection centres.

Unit 4. Sterilisation, Disinfection and Antisepsis 7 Hours
Control of microbial growth, physical methods of microbial control- principles of effective disinfection, types of disinfectants.

Unit 5. Principles of microbial systematics 8 Hours
Taxonomic ranks, Microbial Taxonomy and phylogeny-classical and molecular characteristics, physiological methods to study microbial communities, Molecular methods to study microbial communities, Bergey's Manual of Systematic Bacteriology.

Unit 6. Applied Microbiology 8 Hours
Overview of applications of microorganisms in agriculture, environment, energy, Food, medical, and industry sectors.

References:

1. Atlas, R. M. Principles of Microbiology 3rd Edition, Wm. C. Brown Pub., Iowa, USA, 2001.
2. Cavicchioli, R. Archaea – Molecular and Cellular Biology, ASM Press, Washington, 2007.
3. Dworkin, M., Falkow, S., Rosenberg, E., Schleifer, K.H., Stackebrandt, E. (Eds.). The Prokaryotes. Vol. I – VII, Springer, 2006.
4. Garrity, G.M. and Boone, D.R. (Eds.), Bergey's Manual of Systematic Bacteriology, 2nd edition, Vol. I, Springer, 2001.
5. Garrity, G.M., Brenner, D.J., Kreig, M.R. and Staley, J.T. (Eds.), Bergey's Manual of Systematic Bacteriology, 2nd edition, Vol. II, Springer, 2005.
6. Tortora GJ, Funke BR and Case CL. Microbiology: An Introduction. 9th edition, Pearson Education, 2008.
7. Madigan, M.T. and Martinko, J.M. Brock Biology of Microorganisms, 11th edition, Pearson Prentice Hall, 2006.
8. Mueller, G.M., Bills, G.F. and Foster, M.S. Biodiversity of Fungi – Inventory and Monitoring Methods, Elsevier Academic Press, 2004.
9. Willey, J.M., Sherwood, L.M. and Woolverton, C.J. Prescott, Harley and Klein's Microbiology, 7th edition, McGraw Hill, 2008.

L	T	P	C
3	-	-	3

Course Code	**6SL203CC26**
Course Title	**Metabolism**

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

CO1 Understand the metabolic pathways - the energy-yielding and energy requiring reactions in life; understand the diversity of metabolic regulation, and how this is specifically achieved in different cells
CO2 Evaluate the different metabolic process occurring in the cells
CO3 Relate the link between the metabolic processes and their regulation as a response to external and internal factors
CO4 Analyse the differences and similarities between the various anabolic and catabolic processes occurring in the body

Syllabus: Teaching Hours:45

Unit 1: Metabolism of Carbohydrates 5 Hours
Glycolysis, citric acid cycle, pentose phosphate pathways, glycogenesis and glycogenolysis and their regulation, Gluconeogenesis, and its regulation. Metabolism of Fructose and Galactose. Hormonal regulation of carbohydrate metabolism.

Unit 2: Metabolism of Lipids: 8 Hours
Synthesis of various lipids, bile acids and cholesterol. Elongation of fatty acids, Desaturation of fatty acids in microsomes. Regulation of fatty acid synthesis, Cholesterol metabolism. Composition and synthesis of basic groups of Lipoproteins and their changes during transport in the body.

Unit 3: Metabolism of Amino Acids: 8 Hours
General reactions of amino acid metabolism: transamination, oxidative deamination and decarboxylation. Catabolic fate of □-amino acids and their regulation, glucogenic and ketogenic amino acids. Urea cycle and its regulation. Amino acid biosynthesis.

Unit 4: Metabolism of Nucleotides: 8 Hours
Biosynthesis of purines and pyrimidine- De novo and salvage pathways and their regulation. Catabolism of purines and pyrimidine. Biosynthesis of ribonucleotides and deoxyribonucleotides.

Unit 5: Enzymes: Basic Bio-thermodynamics 8 Hours
Enzyme classification and nomenclature, Enzyme kinetics: Michaelis-Menten equation: Formula, Derivation and Significance; Alternate plotting procedures. Types of Inhibitors and their mode of action.

Unit 6: Enzyme Mechanisms and Regulation: 8 Hours
Different mechanisms of enzyme activity; Strategies for enzyme regulation; Allosteric Enzymes and their Kinetics. Isoenzymes and Multienzyme Complexes.

1. **References:**

2. Voet, D., Fundamentals of Biochemistry, J. Wiley, 2008.
3. Voet, D. and Voet, J. G. Biochemistry, 3rd Edition. John Wiley and Sons, 2004. 3. Boyer, R., Concepts in Biochemistry, Brookes, 1999.
4. Metzler, D. E., Metzler, C. M., Biochemistry: the chemical reactions of living cells. Vols. I and II, Academic Press, 2001.
5. Nelson, D. C. and Lehninger, Principles of Biochemistry, Mac Millan, 2000.
6. Murray, R. K., Granner D. K., Mayes, P. A., Rodwell, V. W., Harper's Biochemistry, 27th Edition, McGraw Hill, 2006.

7. Stryer, L., Bery, J. M., Dymoczko, J. L., Biochemistry Only. 6th edition, WH Freeman and Co. New York, 2006.

L	T	P	C
-	-	10	5

Course Code	**6SL102CC26**
Course Title	**Laboratory I**

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Perform fundamental microbiological, biochemical and cell culture techniques.

CO2 Analyze and interpret the results of biochemical estimations and microbiological experimental data

CO3 Apply techniques to the advanced level practicals and dissertation carried out in further semesters.

Syllabus **Teaching Hours: 192**

1. Introduction to human chromosome complement using Giemsa-stained metaphase cells.
2. Observation of mitotic cell division stages in onion root tip
3. Observation of meiosis stages using fixed slides
4. Demonstration of Short-term blood culture for metaphase chromosome preparation
5. Measurement of microscopic structures using micrometer
6. To study the effect of various parameters viz. inoculum size, aeration, etc. on bacterial growth through the growth curve experiment
7. Estimation of bacterial load in various environmental/ food samples through viable counting
8. Gram-staining
9. Bacteriophage isolation from sewage sample
10. Enzyme assay for Amylase under various conditions
11. Sample Preparation and Separation of Amino Acids, Lipids and Sugars by TLC.
12. Estimation of bio-molecules (Sugar, Protein, Cholesterol, Urea) by spectrophotometer
13. Isolation of Genomic DNA from E.coli
14. Isolation of Plasmid DNA from E.coli
15. Quantification and analysis of DNA
16. Regulation of lac operon in E.coli

References:

1. Patel, RJ. Experimental Microbiology. Vol-1, Aditya Publishers, India, pp: 60-61, 2009
2. Sherma, Joseph, and Bernard Fried, 2nd eds. Handbook of thin-layer chromatography. CRC press, 2007.
3. Stahl, Egon, 2nd eds. "Thin-layer chromatography: a laboratory handbook." Thin-layer chromatography: a laboratory handbook. 2007.
4. Cappuccino, James G., and Natalie Sherman, 7th eds. "Microbiology: A laboratory manual." Addision-six 1999 2007.
5. Mu, Plummer, and David T, 3rd eds. Plummer. Introduction to practical biochemistry. Tata McGraw-Hill Education, 2007.
6. Bates, Steven E. "Classical cytogenetics: karyotyping techniques." Human Pluripotent Stem Cells. Humana Press, 177-190, 2011..
7. Rao, Beedu Sashidhar and Deshpande, Vijay, Experimental Biochemistry, A student Companion, I. K. International Pvt. Ltd, 2005
8. Tom Maniatis, E. F. Fritsch, Joseph Sambrook, Molecular cloning-a laboratory manual, 3rd eds, Cold Spring Harbor Laboratory, 2001
9. Primrose, S. et.al., 7th eds. Principles of Gene Manipulation. Oxford: Blackwell Science, 2008 2001.
10. Prescott.L.M, 7th eds. Microbiology, McGraw Hill Publication, 2008
11. Mitosis, Meiosis and Genetics, J. L. Stein Carter & D. B. Fankhauser, Genetics, 2010.
12. Alberts, Bruce, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts and Peter Walter. Molecular Biology of the Cell. 6th ed. New York: Garland Science, Taylor and Francis Group, LLC, 2015.

Supplementary Course

L	T	P	C
1	-	-	1

Course Code	**6SL801CC26**
Course Title	**Scientific Communication - I**

Course Learning Outcomes:

At the end of the course, students will be able to-

CO1 Understand the basics of English grammar, phonetics, and mechanics of language

CO2 Use appropriate English vocabulary for fluent and confident communication in English

CO3 Demonstrate communication capacities in speaking, writing, listening, and narrating in English

Syllabus: **Teaching Hours: 15**

Unit 1: Introduction to communication

Idioms & Phrases, Basic Nonverbal communication, Barriers to Communication,

Unit 2: Business Communication at work place

Letter components and layouts, planning a letter, Process of Letter writing, Email Communication, Employment Communication, Notice Agenda and Minutes of Meeting

Unit 3: Report Writing
Effective Writing, Types of Business Reports, Structure of Reports, Gathering Information, Organization of Material, Writing Abstract and Summaries, Writing Definitions, Meaning of Plagiarism and Precaution.

Unit 4: Required Skill
Reading Skill, Note-Making, Precise Writing, Audio visual Aids, Oral Communication.

Unit 5: Mechanics of Writing
Transition, Spelling Rules, Hyphenation, Transcribing Numbers, Abbreviating Technical and Non-Technical Terms, Proof Reading.

References:

1. Technical Communication: Principles and Practice, by Meenakshi Raman and Sangeeta Sharma, Oxford University Press, IInd Edition

SEMESTER II

Core Courses

L	T	P	C
3	-	-	3

Course Code	**6SL403CC26**
Course Title	**Industrial Microbiology & Fermentation Technology**

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

CO1 Get acquainted with the industrial aspect of the field of Microbiology, and also learn about growth pattern of microbes in different industrial systems
CO2 Acquire experimental knowhow of microbial production of various industrial products such as alcohol, exopolysaccharides, enzymes, etc.
CO3 Develop an understanding of process control, upstream and downstream process.

Syllabus: **Teaching hours**:**45**

Unit 1: Overview of Microbial Fermentation Industry **7 Hours**
Range of fermentation processes; Diversity of microbes used as process organisms; Potential use of crude glycerol, and lignocellulosic hydrolysates as fermentation substrate with respect to sustainable development.

Unit 2: Screening and Strain Improvement **7 Hours**
Fundaments and concepts on screening of microorganisms for biotechnological applications; Genetic improvement of processes yielding microbial products.

Unit 3: Fermentor **8 Hours**
Design and Operation: Fundamentals of fermentation media and sterilization; Solid state and liquid state bioreactors; Bioprocess intensification and Scale-up.

Unit 4: Bioprocess Monitoring and Control **8 hours**
Biosensors; Bioprocess simulation and economics; Artificial intelligence in bioprocess industry

Unit 5 Downstream Processing **7 Hours**
Unit operations; Cell separation and disruption, product recovery and purification

Unit 6: Industrial Production of Representative Products **8 Hours**
Microbial production of organic acids, antibiotics, amino acids, ethanol, vitamins, enzymes, r-DNA products, probiotics, etc.

References:

1. Biochemical Engineering, Aiba, S., Humphrey,A.E. and Millis, N.F. Univ. of Tokyo Press.
2. Process engineering in Biotechnology, Jackson, A. T. Prentice Hall, Engelwood Cliffs.
3. Biochemical Reactors, Atkinson, B., Pion Ltd, London.
4. Fermentation Microbiology & Biotechnology, E L - Mansi and Bryce, Taylor & Francis, 1999.
5. Industrial Microbiology, Prescott & Dunn, Fourth Edition.
6. Industrial Microbiology by Casida. LE, New age International (P) Limited, Publishers.
7. Industrial Microbiology by Prescott & Dunns, AVI Publishing Company Inc.
8. Industrial Microbiology by A.H. Patel.
9. Principles of Fermentation Technology by P.F. Stanbury, A. Whitaker and S.J. Hall, Butterworth Heineman, Aditya Books (P) Ltd.
10. A text book of Industrial Microbiology by Wulf Crueger and Anneliese Crueger, Panima Publishing Corporation.

L	T	P	C
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Course Code	**6SL104CC26**
Course Title	**Bioanalytical Techniques**

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

CO1 Understand the principles and applications of various techniques used in the isolation, purification, and analysis of biomolecules.
CO2 Apply the concepts of modern anlaytical and instrumental techniques relevant to quantitative measurements in biology
CO3 Justify and relate the selection of bioanalytical methods to characterize a given sample
CO4 Critically evaluate the advantages, limitations, and prospects of various bioanalytical techniques

Syllabus: **Teaching hours: 45**

Unit 1: Separation and characterization of macromolecules **8 Hours**
Principles and applications of ultracentrifugation, ultrafiltration, precipitation, and equilibrium dialysis; Horizontal and vertical electrophoresis. Native and SDS Polyacrylamide gel electrophoresis, 2 D electrophoresis

Unit 2: Chromatography **9 Hours**
Basic principles and applications of Paper chromatography, TLC, Gas Chromatography, Size exclusion chromatography, Ion-exchange chromatography, Affinity chromatography, Reverse phase chromatography, HPLC, FPLC

Unit 3: Spectroscopy **7 Hours**
Basic Principles and Applications of UV/Visible absorption, CD, Raman, Infrared, Fluorescence and Atomic Absorption Spectroscopy

Unit 4: Radioisotope Techniques **6 Hours**
Radioactive decay, half-life, Types of radiations, properties of α, β and γ rays, radioisotope tracer techniques, Measurement of radio activity, autoradiography, radiation protection and measurements, Applications of radioisotopes for analysis of biological samples

Unit 5: Structural determination of Biomolecules **8 Hours**
Basic Principle, instrumentation, and applications of Nuclear Magnetic Resonance & ESR, X-Ray Crystallography, Mass Spectrometry

Unit 6: Microscopy: **7 Hours**
Principles and applications of bright field, dark field, phase contrast, DIC etc., fluorescence, confocal, deconvolution, super-resolution, multiphoton, SEM, TEM, and various types.

References:

1. Pattabhi, V. and Gautham, N. Biophysics, Kluwer Academic Publishers, 2002.
2. Cooper, A, Biophysical Chemistry, Royal Society of Chemistry, 2004.
3. Christian, G. D., Analytical Chemistry, John Wiley & Sons (Asia) Pvt. Ltd., 2004.
4. Hammes, G. G., Spectroscopy for Biological Sciences, John Wiley & Sons, 2005.
5. Westmeier, Reiner, Electrophoresis in Practice;Wiley-VCH Verlag Gmbh. 2005
6. Michael Hoppert; Microscopic Techniques in Biotechnology, John Wiley & Sons, Inc. 2006
7. Skoog, D. A., Holler, F. J. and Crouch, S. R., Instrumental Analysis, Brooks/Cole Cengage Learning, 2007.
8. Roberts, K., Lewis J., Alberts B., Walter P., Johnson A., and Raff. M., Molecular Biology of the Cell, 5th Edition, Garland Publishing Inc., 2008.
9. Wilson, K. and Walker, J. ; Principles and Techniques of Biochemistry and Molecular Biology, 7th edition, Cambridge University press., 2010
10. Robert L. Wixom and Charles W. Gehrke, Chromatography: A Science of Discovery. John Wiley & Sons, Inc. 2010
11. Bhasin, S. K.;, Pharmaceutical Organic Chemistry; Elsevier India Pvt. Ltd.. 2012
12. Monk, Paul, Physical Chemistry: Understanding our Chemical World; John Wiley and Sons. 2013
13. Peter Jomo Walla.; Modern Biophysical Chemistry: Detection and analysis of Biomolecules: Wiley Publishing. 2014.

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Course Code	**6SL303CC26**
Course Title	**Genetic Engineering**

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-
CO1 Understand the fundamental concept of genetic engineering
CO2 Analyse the technique of genetic engineering
CO3 Apply the concept and techniques in designing and conducting experiments and research

Syllabus: **Teaching hours**: **45**

Unit 1: Fundamental Tool and Technique in Recombinant DNA Technology: **5 Hours**
Restriction endonucleases (RE), ligases, alkaline phosphatase, polynucleotide kinase, methylases, terminal transferases, DNase, reverse transcriptase, blunt end ligation strategies, adapters, linkers, homopolymer tailing, RE independent cloning strategies. DNA polymerase I, Klenow fragment, nick translation,

nucleotide probes, and their applications.

Unit 2: Cloning Vehicles and their Application: **8 Hours**

Cloning vectors, Definition, and properties of cloning vectors - plasmids, bacteriophage lambda and M13 -based vectors, cosmids, and shuttle vector, YAC and BACs, viral vector (SV40, retrovirus, and Adenovirus), Ti and Ri Plasmids, cloning of PCR product, TA, and TOPO cloning, subcloning and GATWAY cloning.

Unit 3: Genomic and cDNA Library: **8 Hours**

Strategies for Construction of Genomic library, Construction of cDNA library- mRNA enrichment, Reverse transcription, Selection, and screening of recombinant clones- screening of genomic and cDNA libraries

Unit 4: Gene manipulation and in-vitro mutagenesis: **8 Hours**

Gene knockdown and knockout, Zinc Finger Nucleases (ZFN), CRISPR/Cas9, TALEN, RNAi, and antisense, site-directed mutagenesis, protein Engineering, and transposon tagging.

Unit 5: Expression Strategies for Heterologous Genes: **8 Hours**

DNA Transfection methods, Reporter gene assays, Expression systems (Bacteria, Yeast, Insect, and mammals).

Unit 6: Application of DNA Recombinant Technology: **8 Hours**

Biopharming, genetically modified organisms (microbes, plants, and animals) and their applications in medicine, agriculture, and industry; Gene mapping, therapies for genetic diseases, Ethical considerations, regulatory frameworks in gene editing and genetic engineering.

References:

1. Brown, T.A. (2020). Gene Cloning and DNA analysis. 8th Ed. Wiley Blackwell UK.
2. Primrose, S.B., & Twyman, R.M. (2014). Principles of Gene Manipulation and Genomics. Seventh Edition. Wiley Blackwell UK.
3. Sambrook, J., Fritsch, E. F., & Maniatis, T. (1989). Molecular cloning: a laboratory manual, Vol I, II and III. Cold Spring Harbor Laboratory Press. 3rd revised edition.
4. Watson JD. Caudy AA. Myers RM., Witkowski JA. (2007) Recombinant DNA: Genes and Genomes—A Short Course.
5. Nicholl, D. S. (2008). An introduction to genetic engineering. Cambridge University Press.

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Course Code	**6SL404CC26**
Course Title	**Microbial Genetics**

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Identify types of mutations including spontaneous and induced mutations and understand mechanisms of mutagenesis, DNA damage repair and DNA recombination pathways

CO2 Understand molecular mechanisms of gene transfer in microbes and phages and relate the role of these mechanisms for fine structure mapping of genes

CO3 Apply the knowledge on the results of genetic experiments to find out number of genes involved in a process, gene order, distance between genes and fine structure mapping of genes.

CO4 Integrate the role of extrachromosomal elements including plasmids and transposons in genetic analysis and their roles in evolution

Syllabus: **Teaching Hours:45**

Unit I: Mutations, Mutagenesis and DNA Repair **8 hours**

Genotype and phenotype designations, auxotrophic and catabolic mutants, conditional lethal mutants, resistant mutants, Inheritance in bacteria, variations, Luria and Delbruck experiment, types of mutations and base-pair changes: missense, non-sense and frameshift mutations, deletion mutation, duplication mutations, inversions, insertions, reversion versus suppression, intragenic and intergenic suppressors and nonsense suppressors, mechanisms of spontaneous and induced mutations and mutagens, reverse genetics and directed mutagenesis, DNA damage repair and bypass mechanisms: Base excision, nucleotide excision, mismatch repair, SOS response

cs and directed mutagenesis, DNA damage repair and bypass mechanisms: Base excision, nucleotide excision, mismatch repair, SOS response

Unit 2: Phage Genetics **8 hours**

Genomic organization and replication of viruses, T4, T7, M13, Mu and Lambda - lytic and lysogenic cycles, genetic recombination in phages and its applications, fine structure mapping of T4 *rII* locus.

Unit 3: Plasmids **6 hours**

Plasmid structure, Types of plasmids, F plasmid, col plasmid, R plasmids, metal resistance and antibiotic resistance - efflux pump/MDR bacteria, replication of

plasmids, stability of plasmids, basis of plasmid incompatibility, copy number control.

Unit 4: Genetic Analysis of Bacteria 8 hours
Identification and selection of mutants, enrichment of mutants, genetic characterization of mutants: locating mutations by recombination, genetic markers and marker rescue, complementation test, cloning by marker rescue and complementation, genetic crosses in bacteria, mapping of bacterial markers by transduction and transformation, genome mapping by interrupted mating, Microbial Chassis

Unit 5: Genetic Recombination and Transposons 8 hours
Mechanism of recombination - General recombination (Holiday model), site-specific recombination, Role of recombination in DNA damage bypass and repair, Transposable elements - Classes of transposable elements in bacteria and yeast, Insertion Sequences (IS elements), Mechanisms of transposition and retrotransposition.

Unit 6: Gene regulation and genetic models 7 hours
Control of gene expression, Positive and negative gene regulation and attenuation, using the *lac, trp* and *ara* operons, regulation by small molecules, gene silencing (RNAi): an introduction and its application, Model organisms used in genetic studies: Yeast (*Saccharomyces cerevisiae*).

References:

1. Brown, T.A. Genetics - A Molecular Approach, 3rd edition, BIOS Scientific Publishers, 2004.
2. Brown, T.A. Genomes 3, G.S. Garland Science, 2007.
3. Dale, J.W. and Park, S.F. Molecular Genetics of Bacteria, 5th edition, Wiley-Blackwell, 2010.
4. Das, H.K. Textbook of Biotechnology, 2nd edition, Wiley Dreamtech, 2005.
5. Gardner, E.J. Simmons, M.J. and Snustad, D.P. Principles of Genetics, 8th edition, John Wiley and sons, 2004.
6. Krebs, J.E., Goldstein, E.S. and Kilpatrick, S.T. (Eds.), Lewin's Genes X, 10th edition, 2011.
7. Maloy, S.R., Cronan Jr., J.E. and Freifelder, David. Microbial Genetics, 2nd edition, Narosa Publishing House, 2009.
8. Snustad, D.R. and Simmons, M.J. Principles of Genetics, 5th edition, John Wiley and sons, 2010

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Course Code	**6SL205CC26**
Course Title	**Laboratory II**

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-
CO1 Understand the basics of bioinformatics tools, immunological techniques, Industrial microbiology, microbial genetics and experiments related to molecular biology
CO2 Analyze the data obtained from molecular analysis of RNA, DNA and protein
CO3 Apply the techniques based on requirement in analysis of biomolecules and microbiology and for conducting research

Syllabus: Teaching hours: 150

1. Introduction to bioinformatics, computational biology, Genomics, Proteomics
2. Introduction to Biological Databases and Data Retrieval Tools
3. To perform database similarity search of given nucleotide sequence using BLAST
4. Introduction to and Retrieval of protein structures from the PDB
5. To learn searching using PubMed: The Bibliographic Database
6. To learn drawing chemical compound structures
7. Performing Multiple Sequence Alignment with Clustal Omega
8. To isolate genomic DNA from bacteria by CTAB method
9. To resolve the purified samples of plasmid and genomic DNA using agarose gel electrophoresis
10. Study of Polymerase Chain Reaction (PCR)
11. Plasmid DNA isolation from E.coli using alkaline lysis method
12. Perform direct ELISA (Enzyme Linked Immuno-Sorbent Assay)
13. Purification of IgG by Ion-exchange chromatography
14. Purification of IgG by Affinity chromatography
15. Perform Western Blot
16. RNA isolation
17. cDNA Synthesis and qPCR
18. Study of UV survival curve for E. coli and Serratia marcescens by Plate count method
19. To determine effect of UV radiation on pigmentation of Serratia marcescens
20. To study the effect of incubation temperature on pigmentation of S. marcescens
21. Induction of the Lac operon in E. coli
22. To isolate antibiotic resistant mutants

23. To produce citric acid fermentatively by Aspergillus niger and carry out its crude recovery and estimation
24. Alcohol fermentation from grapes, molasses,etc. and Alcohol Estimation
25. Protocol for isolation and cultivation of heterotrophic bacteria from water samples
26. Qualitative assessment of enzyme activity in microorganisms isolated from water samples
27. Biofilm Quantification from Heterotrophic Bacterial isolates.

Supplementary Courses

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Course Code	**6SL802CC26**
Course Title	**Scientific Communication - II**

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Develop novel topics about which they wish to communicate

CO2 Use electronic databases to perform literature searches for information

CO3 Synthesize this information and information from other sources to formulate clear, logical theses and arguments about their topics

Syllabus: **Teaching Hours:15**

Unit 1: Scientific Communications **7 Hours**

Importance of communication in science, Types of communications, Communicating with scientific and non-scientific audiences, Verbal, and presentation skills: Oral and Poster Presentations, Graphical abstract.

Unit 2: Writing Skills **8 Hours**

Writing of Books and Research Papers, Report and thesis Writing, Formats of Publications in Research Journals

References

1. Scientific Communication- An introduction https://doi.org/10.1142/11541 | March 2020, pages 276
2. Science communication: A practical Guide for scientists, Laura Bowater, Kay Yeoman, ISBN: 978-1-118-40666-3 October 2012 Wiley-Blackwell
3. Joseph E. Harmon and Alan G. Gross. The Craft of Scientific Communication. University of Chicago Press; 2010.

Elective Courses I

L	T	P	C
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Course Code	**6SL106ME26**
Course Title	**Nanobiotechnology**

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Understand the basics of nanotechnology and biomaterials

CO2 Understand the different types of formulation and factors affecting them

CO3 Analyse the Biological Interactions with nanomaterials

CO4 Evaluate the risk assessments involved bio nano materials

Syllabus: **Teaching Hours: 45**

Unit 1: Basics of Nanobiotechnology **8 Hours**

Origins of nanotechnology, Definitions and scales, size scale effects; Current state of Nanotechnology, Future of Nanotechnology; Nanotechnology in Nature and applications; Nanotechnology in Biology; Mechanism of biological systems at nanoscale; biological motors, Biophotonic devices, Introdution to DNA Nanotechnology.

Unit 2: Sustained, Controlled Release formulation and Nano-Based Drug Delivery System **8 Hours**

Introduction & basic concepts, factors influencing, Physicochemical & biological approaches for SR/CR formulation, Mechanism of Drug Delivery from SR/CR formulation, Customized drug delivery systems; Polymeric Micelles, Solid Lipid Nanoparticles, their types, Synthesis, Characterization, and applications.

Unit 3: Nanomaterials and Biomaterials **8 Hours**

Molecular building blocks for nanostructure systems, Nanomaterials – formation of materials, carbon nanomaterials, Buckyball, Graphene (2D), Carbon nano tubes, Inorganic nano materials, Zero Dimensional Nano-Structures, One Dimensional Structures, 2D and 3-D Structures; Properties of biomaterials, Surface, bulk, mechanical and biological properties. Scaffolds & tissue engineering, Types of biomaterials, example of biological and synthetic materials, Biopolymers, Liposomes, Applications of biomaterials, Modifications of Biomaterials.
fications of Biomaterials.

Unit 4: Models of Nano and Bionanosystems **7 Hours**

Lipid Bilayers, liposomes, neosomes, Phytosomes, Polysacharides, Peptides, Nucleic acids, DNA scaffolds, Enzymes - Biomolecular motors: linear, rotary motors. Immunotoxins, Membrane transporters and pumps, Antibodies, monoclonal Antibodies, immunoconjugates. Limitations of natural biomolecules.

Unit 5: Biological Interactions with Materials and Bioaccumulation **7 Hours**

Biocompatibility, Cellular uptake mechanisms; Granulation Tissue Formation, Foreign body reaction, Fibrosis, Blood-Biomaterial interactions, Interactions with Proteins, , The Vroman Effect, Fibrous Capsule Formation, Safety Testing of Biomaterials. Exposure mechanisms, Subcellular localization, biodistribution, clearance mechanism, metabolism, and excretion of nanomaterials.

Unit 6: Regulatory Considerations for Drug Delivery Systems 7 Hours

Indian drug regulatory authorities, FDA, Drugs and Cosmetics Act, ICH and OECD Guidelines, Regulatory aspects of pharmaceutical and bulk drug manufacture, regulatory drug analysis; Predictive Nanotoxicology using QSAR and QSPR models, Immunotoxicity of nanomaterials.

References:

1. Bernard N. Kennedy (editor). New York: Nova Science Publishers, 2008.Stem cell transplantation, tissue engineering, and cancer applications
2. Biomaterials: A Nano Approach,S Ramakrishna, M Ramalingam, T.S. Sampath Kumar, Winston O. Soboyejo,Published by CRC Press
3. Bionanotechnology: Lessons from Nature, D S. Goodsell, by John Wiley & Sons, Inc.
4. Chris Binns, "Introduction to Nanoscience and Nanotechnology", John Wiley and Sons 2010
5. Fadeel, B (2015): Handbook of Safety Assessment of Nanomaterials: From Toxicological testing of Personalized Medicine, Stanford Publishing, Singapore.
6. Fenghua Meng, Zhiyuan Zhong and Jan Feijen (2009): Stimuli-Responsive Polymersomes for Programmed Drug Delivery. Biomacromolecules, Biomacromolecules, 10(2): 197-209.
7. Fritz Allhoff, Patrick Lin, and Daniel Moore, "What Is Nanotechnology and Why Does It Matter" WILEY BLACKWELL A John Wiley & Sons, Ltd., Publication, 2010
8. James Swarbrick (2010). Novel Drug Delivery Systems. Informa healthcare
9. Kreuter J. (2012): Colloidal Drug delivery System, Marcel Dekker, USA.
10. Mark A. Reed and Takhee Lee, "Molecular Nano electronics", American Scientific Publishers, 2003.
11. Naik J (2015). Nano Based Drug Delivery. IAPC Publishing, Zagreb, Croatia
12. Nanobiotechnology: Concepts, Applications and Perspectives, (edited by C. M. Niemeyer and C. A. Mirkin), Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim,
13. Nanobiotechnology: Concepts, Applications and Perspectives, Edited by Christof M. Niemeyer and Chad A. Mirkin, Wiley-VCH, 2004.
14. Nanofabrication towards Biomedical Applications, Techniques, Tools, Applications, and Impact. C. S. S. R. Kumar, J. Hormes, C. Leuschner, 2005, WILEY -VCH Verlag GmbH & Co. KGaA
15. Nanoparticulates Drug Carriers, Edited by Vladimir P Torchilin, 2006, Imperial College Press, 57 Shelton Street, Covent Garden.
16. Nanoscale Technology in Biological Systems, Edited by Ralph S. Greco, Fritz B. Prinz, R. Lane Smith, CRC PRESS, Boca Raton London New York Washington, D.C. Copyright © 2005 by Taylor & Francis
17. R. Lanza, I. Weissman, J. Thomson, and R. Pedersen, Handbook of Stem Cells, TwoVolume, Volume 1-2: Volume 1-Embryonic Stem Cells; Volume 2-Adult &Fetal Stem Cells, 2004, Academic Press.
18. R. Lanza, J. Gearhart etal (Eds), Essential of Stem Cell Biology, 2006, ElsevierAcademic press.
19. Ranade VV and Cannon JB (2015). Drug Delivery Systems. CRC Press.
20. Raphael Gorodetsky, Richard Schäfer. Cambridge: RSC Publishing, c2011.Stem cell based tissue repair.
21. Robinson JR, Lee VHL (2013). Controlled Drug Delivery Systems, Marcel Dekker, USA.

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Course Code	**7SL304ME26**
Course Title	**Vaccinology**

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Have an idea about the history of various vaccines (subunit vaccines, peptide, DNA and RNA vaccines, live & killed vaccines, and edible vaccines), composition of vaccines

CO2 Learn and develop understanding on the effective delivery of developed vaccine formulation to achieving robust immune responses

CO3 Understand the various methods to develop vaccines against viral diseases including, HIV, hepatitis, flu etc.

CO4 Learn and understand the basics of bacterial, protozoan vaccines with reference to malaria

parasite

CO5 To design an efficacious vaccine based on our understanding of the immune response generated due to natural infection as well as the same induced by successful vaccines tried in human beings since 18th century.

Syllabus: **Teaching hours**: **45**

Unit 1: Classification of Vaccines **7 Hours**

History of vaccines, Immunological principles, Composition of vaccines: vaccine, adjuvant, conservative Concepts of vaccine development, types of vaccine (Conventional vaccines; Live attenuated and killed vaccines; Subunit vaccines; Synthetic peptide vaccines; Anti-idiotype vaccines; Recombinant DNA vaccines; Deleted mutant vaccines; Reassortment vaccines; DNA vaccines; mRNA vaccines, Edible vaccines, heat killed, X-irradiated, or live attenuated whole pathogen, toxoid vaccines, challenges and possibilities with new vaccines and vaccine strategies

Unit 2: Adjuvants and Mucosal Vaccine Delivery **6 Hours**

Novel adjuvants (targeting TLR and non-TLR based PRRs, metabolic adjuvants, cell death adjuvants, epigenetic adjuvants), vaccine formats (DNA, viral vectors, dendritic cells), Immunobiology of classic adjuvants with examples: Alum, emulsion adjuvants, Carriers; Haptens; Vaccine delivery methods and delivery mechanisms: nanoparticles, polymeric biomaterials, targeted delivery mechanisms, virus-like particles (VLP) and self-assembling peptide scaffolds.

Unit 3: Vaccines for viruses **8 Hours**

HIV, CMV, Influenza, Hepatitis, herpes viruses, Conventional vaccines killed and attenuated, modern vaccines: recombinant proteins, subunits, DNA vaccines, peptides, immunomodulators (cytokines), Antisense RNA, siRNA, ribozymes, in silico approaches for vaccine design.

Unit 4: Vaccine for bacteria and parasites **8 Hours**

Shigella, vibrio cholera, diphtheria, tetanus, pertusis, pneumococcus meningitis, mycobacterium (BCG), toxoplasma; Malaria, Leishmaniasis, Entamoeba histolitica, schistosomiasis and other helminthic infections

Unit 5: Antigen Prediction for B and T cells and Validation **8 Hours**

Fundamentals of B cell and T cell epitope recognition, Databases in Immunology, linear and conformational B-cell epitope prediction methods, T-cell epitope prediction methods, Resources to study antibodies, antigen-antibody interactions, QAM (Quantitative Affinity matrix), Structure Activity Relationship – QSARs and QSPRs, QSAR Methodology, Methods for validating predicted B and T cell epitopes.

Unit 6: Vaccine Development and Standardization **8 Hours**

Vaccine development pathway (vaccine design, pre-clinical studies, clinical trials (phase-I, phase-II and phase-III), vaccine registration, post-market surveillance, vaccine efficacy and vaccine effectiveness, standardization of vaccines, vaccine characterization, potency, stability, sterility and safety.

References:

1. Plotkin, S. A., Orenstein, W. A., and Offit, P. A., Vaccines. 5th Edition, Elsevier, 2008.
2. Immunopotentiators in Modern Vaccines by Schijns and O'Hagen
3. Robinson, A., Hudson, M.J., Cranage, M.P. Vaccine Protocols, C Second Edition, Humana Press, NY, 2003.
4. Chimeric Virus like Particles as Vaccines. Wolfram H. Gerlich (Editor), Detlev H. Krueger (Editor), Rainer Ulrich (Editor), November 1996 Publisher: Karger, S. Inc
5. Kindt, Kuby-Immunology (complements)
6. Current protocols in Immunology
7. Complement regulators and inhibitory proteins. Nat immunology Review volume 9, Oct 2009, 729-40

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Course Code	**6SL405ME26**
Course Title	**Microbial Ecology**

Course Learning Outcomes:

At the end of the course, the student will be able to

CO1 Understand principles of ecology and interactions among microorganisms and different environment

CO2 Analyze beneficial and pathogenic interactions of microorganisms with plants and animals

CO3 Importance of microbial diversity and conservation

CO4 Comprehend role of microorganisms in biogeochemical cycling of elements

Syllabus: **Teaching Hours: 45**

UNIT I: Fundamentals of Ecology **7 Hours**

The basic concept of ecosystem, habitat and niche; energy in ecological systems; energy partitioning in food chains and food webs; history and scope of ecology.

UNIT II: Microbial interaction in Biotic and Abiotic Environment **6 Hours**

Interaction between diverse microbial population in biotic environments; Conflictual interactions – parasitism - predation - antibiosis – competition; Beneficial interactions – co-metabolism – mutualism – cooperation – commensalism; Microbial interactions in abiotic environments.

UNIT III: Interactions between Microorganisms and Plants & Animals **8 Hours**

Interaction with plant roots–rhizosphere & mycorrhizae; microbial diseases of plants. Microbial contribution to animal nutrition; novel prokaryotic endosymbionts, ecological aspects of animal diseases.

UNIT IV: Importance and Conservation of Microbial Diversity **8 Hours**

Importance of microbial diversity in environment, pharmaceuticals & human health. Importance of conservation. Metagenomics. *In situ* conservation and *Ex situ* conservation. Role of culture collection centers in conservation.

UNIT V: Biogeochemical cycling I **8 Hours**

Carbon cycle, Hydrogen cycle, Oxygen cycle

UNIT VI: Biogeochemical cycling II **8 Hours**

Nitrogen cycle, Sulphur cycle, Phosphorus cycle, cycling of other elements

References:

1. Environmental Microbiology and Biotechnology by Singh and Dwivedi. New Age Int. Sci. Publication.
2. Atlas, R.M. and Bartha, R. Microbial Ecology, 4th edition, Pearson Education, 2009.
3. Maier, R.M., Peppper, I.L. and Gerba, C.P. Environmental Microbiology, 2nd edition, Elsevier Academic Press, 2009.
4. Paul and Clerk, Soil Microbiology and Biochemistry, 2007.
5. Paul, E.A. (Ed.). Soil Microbiology, Ecology and Biochemistry, 3rd edition, Academic Press, 2007.
6. Pepper, I.L. and Gerba, C.P. Environmental Microbiology – A Laboratory Manual, 2nd edition, Elsevier Academic Press, 2005.
7. Manahan, S.E. Environmental Chemistry, 9th edition, CRC Press, 2010.
8. Odum, E.P. and Barrett, G.W, Fundamentals of Ecology, 5th edition, Cengage Learning, 2005 Microbial Ecology by Alexander. Willey Publication.
9. Oladele Ogunseitan (2004) Microbial Diversity: Form and Function in Prokaryotes; Wiley- Blackwell.
10. Satyanarayana, T., Johri, B. N. (2005) Microbial Diversity: Current Perspectives and Potential Applications; I.K. International Publishing House Pvt., Limited.
11. James W.Brown (2014) Principles of Microbial Diversity; ASM Press.
12. Colwell, R. R., Simidu, Usio, Ohwada, Kouicki (1996) Microbial Diversity in Time and Space; Springer.

SEMESTER III

Core Courses

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Course Code	**7SL405CC27**
Course Title	**Molecular Microbial Physiology**

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Describe` the principles of the energy-yielding and -consuming reactions, the various catabolic and anabolic pathways, the transport systems, and the mechanisms of energy conservation in microbial metabolism

CO2 Recognize the extent of metabolic diversity present in this microbial world and identify various physiological groups of bacteria with their metabolic special features

CO3 Analyze microbial physiology related topics by working on assignments and to compose a concise report

CO4 Critically think and integrate conceptual information into an understanding of signal transduction, adaptation to stress and differentiation of microbial systems

Syllabus: **Teaching hours**: **45**

Unit 1: Central Metabolism **10 Hours**

Glycolysis, ED pathway, phosphoketolase pathway, oxidative pentose phosphate pathway TCA cycle, glyoxylate cycle, gluconeogenesis, regulatory aspects, Metabolism of sugars other than glucose

Unit 2: Electron transport chains and Phototrophy **9 Hours**

Mitochondrial and bacterial electron transport chains, Aerobic respiration and anaerobic respiration, Bacteriorhodopsin, and energy generation, oxygenic and anoxygenic Photosynthesis. Mechanism of photosynthesis in bacteria, cyanobacteria, and algae

Unit 3: Chemolithotrophy and CO_2 **10 Hours**

fixation
Nitrate reduction: assimilatory vs. dissimilatory, nitrification, denitrification, electron transport in iron bacteria, Sulphur bacteria, Calvin cycle, reductive TCA cycle

Unit 4: Signal Transduction in Prokaryotes **6 Hours**
Two component system, Phosphorelay, Chemotaxis-Genes and Proteins involved in chemotactic response to attractant and repellent.

Unit 5: Microbial Adaptation to stress **6 Hours**
Temperature, salt and osmotic stress and oxidative stress, Quorum sensing.

Unit 6: Differentiation in Microbial Systems **4 Hours**
The model of Sporulation in Bacillus, the two-component signalling system, stages of Sporulation, Proteins and genes involved in Sporulation.

References:

1. White, D., Physiology and Biochemistry of prokaryotes, 3rd Edn. Oxford Univ. Press, 2007.
2. Moat, A. G. and Foster, J. W., Microbial Physiology, 3rd Edition, Wiley-Liss Publ, 1995.
3. E. L. Sharoud, Bacterial Physiology – A Molecular Approach, Springer, 2008.
4. Byung Hong Kim, Geoffrey Michael Gadd, Bacterial Physiology and Metabolism, Cambridge University Press, Cambridge, 2008.
5. Doelle HW, Bacterial Metabolism, Elsevier India Pvt. Ltd., New Delhi, 2005.
6. Gerhard Gottschalk, Bacterial Metabolism, 2nd edn., Springer-Verlag, New York, 2006.

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Course Code	**7SL302CC27**
Course Title	**Genomics and Proteomics**

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-
CO1 Describe the understanding of origin and evolution of genomics and gene mapping
CO2 Apply the knowledge to establish new, molecular classification of the disease
CO3 Evaluate the possibilities for application of pharmacogenomics and proteomics in drug discovery and development of personalized medicine

Syllabus: **Teaching Hours: 45**

Unit 1: Origin and Evolution of genomics and gene mapping **8 Hours**
Origin of genomics, the first DNA genomes, genomes and human evolution, evolution of nuclear, mitochondrial and chloroplast genome, the concept of minimal genome and possibility of synthesizing it, genetic maps, physical maps, functional maps, comparative genomics, and collinearity, synteny in maps.

Unit 2: Whole Genome sequencing technologies and genome assembly **8 Hours**
Principle of genome sequencing tools, automated Sanger sequencing, pyrosequencing, Illumina. oxford nanopore and PacBio Sequencing. Whole genome assembly pipeline. k- Mer de Bruijn graph. Human, Arabidopsis, and Drosophila genome

Unit 3: Functional genomics **6 Hours**
Concept of forward and reverse genetics, insertion mutagenesis (T-DNA and transport insertion), Targeting Induced Local Lesions in Genomes (TILLING), gene expression and transcript profiling, EST contigs, use of DNA chips and microarrays

Unit 4: Principle of basic protein preparation and separation **8 Hours**
Preparation of protein isolates and fractionation /separation of proteins and peptides - basic methods of protein isolation from various sample types; electrophoretic separation techniques (IEF, SDS-PAGE, 2-D gel electrophoresis, DIGE, etc.); liquid chromatography (HPLC and FPLC); separation procedures for analysis of phospho-proteins and glycosylated proteins: multidimensional procedures for analysis of complex protein samples.

Unit 5: Strategies for protein identification **8 Hours**
Mass-spectrometry of proteins - basic types of ionization techniques (ESI and MALDI) and hybrid instruments (TOF, ion trap and FTMS); protein identification methods; characterization of protein modifications. methods of protein quantification (relative and absolute quantification techniques)

Unit 6: Protein interactomes and protein modification in Proteomics and application **7 Hours**
Methods of protein-protein interaction study (Y2H, tagging TAP, FLAG, His; ion mobility utilization); Phosphoproteomics, Glycoproteomics, protein microarray. Human proteome project. application of proteomics in diagnostic, drug development and agriculture.

References:
1. Pevsner, J., Bioinformatics and Functional Genomics, Second Edition, Wiley-Blackwell, 2009.
2. Mount, D. W., Bioinformatics: Sequence and Genome Analysis, CBS Publishers, 2004
3. Liebler, D., Introduction to Proteomics: Tools for New Biology, Human Press Totowa, 2002.
4. Campbell, A.M. & Heyer, L.J., Discovering Genomics, Proteomics and Bioinformatics. Benjamin/Cummings, 2002.
5. Twyman, R. Principles of Proteomics. London: Taylor & Francis, 2014.
6. Lovric J. Introducing Proteomics: From Concepts to Sample Separation. Mass Spectrometry and Data Analysis, published by Wiley, 2011

L	T	P	C
3	-	-	3

Course Code	**7SL410CC27**
Course Title	**Medical Microbiology**

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Get acquainted with the molecular basis of pathogenesis and virulence of different microbial pathogens, and would also be sensitized to the social impact of most dreadful infections like tuberculosis, malaria, HIV, etc.

CO2 To acquire experimental knowhow of antimicrobial susceptibility assays, biochemical characterization of medically important microorganisms, etc.

CO3 Develop an understaffed go the problem of drug-resistance, and the mechanism underlying its development and spread among pathogenic populations.

Syllabus: **Teaching Hours: 45**

Unit 1: Overview of Microbial Infections in Humans **7 hours**

Evolution of microbial pathogens; Concepts of virulence, pathogenicity, and epidemiology; Status of the field of microbial pathogenicity

Unit 2: Bacterial Pathogens **7 hours**

Host-pathogen interactions, mechanisms of virulence and antibiotic resistance in important bacterial pathogens listed as Priority Pathogens by WHO/CDC/DBT e.g. *P. aeruginosa*, *S. aureus*, *M. tuberculosis*, etc.; Role of biofilms and quorum sensing in bacterial virulence: Host-pathogen interactions, mechanisms of virulence and antibiotic resistance in important bacterial pathogens listed as Priority Pathogens by WHO/CDC/DBT e.g. *P. aeruginosa*, *S. aureus*, *M. tuberculosis*, etc.; Role of biofilms and quorum sensing in bacterial virulence.

Unit 3: Eukaryotic Pathogens of Humans **7 hours**

Fungi, protozoa, and helminths as pathogens; Host-pathogen interactions, mechanisms of virulence and antibiotic resistance in these parasites

Unit 4: Viral Infections **8 hours**

General characteristics, Pathogenesis, Diagnosis, Mechanisms of viral pathogenesis with reference to representative examples of viruses of pandemic potential e.g. HIV, influenza, coronavirus, etc.; Prions

Unit 5: Treatment and Prevention **8 hours**

An overview of antimicrobial agents in current clinical use, and their modes of action; Antimicrobial Resistance (AMR); Role of lateral gene transfer and pathogenicity islands in spread of AMR; Discovery and development of novel anti-pathogenic agents; Anti-virulence approach; Vaccines; Traditional Medicine in combating AMR.

Unit 6: Human Microbiome in Health and Disease **8 hours**

An overview of human microbiome composition and its correlation with communicable and non-communicable diseases; Probiotic, prebiotics, and their clinical or nutraceutical applications

References:
1. Sasakawa S (2009). Molecular mechanisms of bacterial infection via the gut. Springer.
2. Greenwood D, Slack R, Peutherer J, Medical Microbiology 15th Edn., Churchil and Livinstone. 2007.
3. Schaechter M,. Engleberg, N C, . Einstein B and Mendoff G, Mechanism of Microbial Diseases, 3rd Edition., Williams and Wilkins, 1998.
4. Wilson M (2005). Microbial inhabitants of humans. Cambridge University Press.

L	T	P	C
2	-	-	2

Course Code	**7SL901CC27**
Course Title	**Research Methods**

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Understand the various kind of research designs and their importance in conducting the research work.

CO2 Propose original research proposal and

demonstrate skills for effective communication through its defense

CO3 Application of bio statistical tools for evaluation of statistical relevance of results obtained

Syllabus: **Teaching Hour: 30**

Unit 1: Research **8 Hours**

Definition of Research, Applications of Research and Types, Validity, Literature Review, develop a Theoretical and Conceptual Framework, writing up the Review, Formulating and Research Problem: Sources, Considerations, Definition of Variables, Types, Cooperative vs Collaborative Research; Disruptive vs Developmental Research; Research Modeling: Types of Models, Model Building and Stages, Data Consideration.

Unit 2: Research Design **10 Hours**

Design of Experiments, Objectives, Strategies, Replication, Randomization, Blocking, Guidelines for Design of Experiments, Simple Comparative Experiments- Two Sample T-Test, P-Value, Confidence Intervals, Paired Comparisons, Single Factor Experiment: Analysis of Variance (ANOVA), Randomized Complete Block Design.

Unit 3: Research Proposal **10 Hours**

Contents-Preamble, The Problem, Objectives, Hypothesis, Study Design, Setup, Measurement Procedures, Analysis of Data, Organization of Report; Displaying Data tables, Graphs and Charts, writing a Research Report- Developing an Outline, Key Elements- Objective, Introduction, Design or Rationale of Work, Experimental Methods, Procedures, Measurements, Results, Discussion, Conclusion, Referencing and Various Formats for Reference.

Unit 4: Ethics and Scientific Conduct **7 hours**

Good Laboratory practice (GLP) – Data Documentation, SOP Plagiarism, Scientific conduct and misconduct, Ethical Guidelines, Biosafety; Principles of Human and Animal Research ethics.

References:

1. Central Drugs Standard Control Organization Http://CDSCO.NIC.IN/
2. Http://WWW.Patentoffice.NIC.IN/
3. WWW.OECD.ORG/DATAOECD/9/11/33663321.PDF
4. Http://WWW.FDA.GOV/FDAC/Special/Testtubetopatient/Studies. Html
5. Ranjit Kumar, Research Methodology- A Step-By-Step Guide for Beginners, Pearson Education, Delhi. 2006.
6. Trochim, William M.K., 2/E, Research Methods, Biztantra, Dreamtech Press, New Delhi, 2003.
7. Montgomery, Douglas C. 5/E, Design and Analysis of Experiments, Wiley India, 2007.
8. C.R. Kothari and Gag, Gaurav, Research methodology- Method and Techniques, New Age International, New Delhi, 2019.
9. Besterfield, Dale H. 3/E, Total Quality Management, Pearson Education, New Delhi, 2005.
10. C. George Thomas, Research Methodology and Scientific Writing, New Delhi, 2015.
11. G Nageswara Rao, Biostatics and Research Methodology, Hyderabad, 2018.
12. Kartikeyan, S. Chaturvedi, R.M and Bhosale, Comprehensive Textbook of Bio-statics and Research Methodology, Mumbai, 2016.

L	T	P	C
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Course Code	**7SL204CC27**
Course Title	**Laboratory III**

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Demonstrate the skill to design controlled experiments for performance of standard practicals to understand the physiology and adaptation of microbial systems in different environments.

CO2 Record and report experimental results in standard format and derive coherent conclusions of results stating their significance.

CO3 Correlate the theoretical concepts to appreciate and evaluate results obtained through scientific enquiry

Syllabus: **Teaching Hour: 150**

1. Estimation of the most probable number (MPN) of sulfate reducing bacteria in soil samples
2. Estimating Soil Microbial activity by dehydrogenase enzyme
3. Physico-chemical characterization of waste water. (DO, Hardness, Dissolved Solids/Suspended solids/Total solids, Chloride, Sulphate)
4. Estimation of BOD.
5. Testing for microbiological quality (Coli-form test) for potable water
6. Biosorption of Metals
7. Perform protein purification by size exclusion chromatography and HPLC
8. Demonstration of flow cytometer using Florescently labeled bacteria

9. Screening of Antibiotic-Resistant Genes in Bacteria Using Polymerase Chain Reaction (PCR)
10. Study on the Dark Repair Mechanism of Escherichia coli and Its Effect on Antibiotic Resistance Pattern
11. *In vitro* Antimicrobial susceptibility testing in line with CLSI guide, Disc diffusion assay, MIC and MBC determination.
12. In vivo antibiotic efficacy assessment in the worm model of infection.
13. Virulence assessment in worm model of infection.
14. Toxicity assessment in the worm model (C.elegans).

References:

1. Doyle, Alan. Cell and tissue culture: laboratory procedures in biotechnology. John Wiley & Sons Ltd, 1998.
2. Freshney, R. Ian. "Basic principles of cell culture." Culture of cells for tissue engineering (2006): 3-22.
3. Freshney, R. Ian. Culture of animal cells: a manual of basic technique and specialized applications. 7th ed., John Wiley & Sons, 2016.
4. Tortora, Gerard J., and Bryan H. Derrickson. Principles of anatomy and physiology. 13th ed. John Wiley & Sons, 2011.
5. McMaster, Marvin C., and A. HPLC. A Practical User's Guide. 2nd ed. Wiley-Vch, 2007.
6. Prajapati, Bhumika, et al. "Divergent outcomes of gut microbiota alteration upon use of spectrum antibiotics in high sugar diet-induced diabetes in rats." RSC advances 8.46 (2018): 26201-26211.

Elective Courses II

L	T	P	C
3	-	-	3

Course Code	**7SL401ME27**
Course Title	**Agriculture & Environmental Microbiology**

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Describe role of microorganism in recycling soil nutrients, biodegradation of complex plant polymers, sustaining and improving plant growth through improving nutrient availability, production of plant growth promoting substances and inhibiting pathogens

CO2 Critically discuss the need for environmental microbiology and agricultural microbiology and explain their limitations

CO3 Clarify application of microorganisms in varied fields of agricultural and environmental microbiology like bioremediation, biofertilizers and waste water treatment

CO4 Analyse various aspects of N_2 fixation, P solubilization, PGPR, biodegradation and bioremediation mechanisms provided by microbes

Syllabus: **Teaching hours:45**

Unit 1: Biological Nitrogen fixation 10 Hours

Physiology and Biochemistry of Nitrogen fixing organisms, Genetics and regulation of nif gene expression, Signalling factors and molecular interaction in establishing Rhizobia legume symbiosis

Unit 2: Phosphate Biofertilizers 6 Hours

PSMs, Inorganic phosphate solubilization and its mechanisms, Phosphate mineralizers – phytate and organic phosphate hydrolyzing bacteria, and Ecto- and Endo- Mycorrhizae

Unit 3: Plant Growth Promoting Rhizobacteria 6 Hours

PGPR in improving plant growth, Mechanism in plant growth promotion, Factors affecting rhizosphere colonization.

Unit 4: Environmental Problems and Monitoring 8 Hours

Pollution and its classification, Effluent standards: examination of waste water characteristics, municipal and industrial waste water, Global environmental problems: global warming, acid rain, ozone depletion, Sampling and analysis, Environmental monitoring and audit, Environmental laws, and policies in India.

Unit 5: Bio-Treatment Kinetics and Reactor Design 8 Hours

Principals of biological treatments, Biological treatments: Composting, Suspended growth systems, Attached growth systems, Bioreactor design: Activated Sludge Process, Tickling Filters, Fluidized bed and Packed bed reactor, Rotating Biological Contractors, Oxidation Ponds and Ditches, Lagoons, Anaerobic Reactors.

Unit 6: Bioremediation and Biodegradation 7 Hours

Bioremediation principles and Processes: Biosorption, Bioaccumulation, Bioconversion, Biotransformation, Bioleaching, Biodegradation, Detoxification, Activation, Acclimatisation and Co-metabolism, strategies and

techniques of bioremediation: in situ and ex situ, of Hydrocarbons, Pesticides and Dyes, GMO's in bioremediation and biodegradation.

References:

1. Alexander, M. Biodegradation and Bioremediation, Academic Press, 1994.
2. Arceivala, S.J. and Asolekar, S.R., Wastewater treatment for Pollution Control and Reuse, 3rd edition, Tata McGraw Hill, 2007.
3. Atlas, R.M. and Bartha, R. Microbial Ecology, 4th edition, Pearson Education, 2009.
4. Bhatia, S.C. Handbook of Environmental Microbiology, Vol. III, Atlantic Publishers, 2008.
5. Das, H.K. Textbook of Biotechnology, 2nd edition, Wiley Dreamtech, 2005.
6. Dworkin, M., Falkow, S., Rosenberg, E., Schleifer, K.H., Stackebrandt, E. (Eds.). The Prokaryotes. Vol .I – VII, Springer, 2006.
7. Evans, G.M. and Furlong, J.C. Environmental Biotechnology – Theory and Application, John Wiley and Sons, 2004.
8. Hurst Christon J., Manual of Environmental Microbiology, ASM Press, Washington DC, 2007 .
9. Khan M. S., Zaidi A. and Musarrat J,. Microbes for legume improvement, Springer Wien, New York, 2010.
10. Maier, R.M., Peppper, I.L. and Gerba, C.P. Environmental Microbiology, 2nd edition, Elsevier Academic Press, 2009.
11. Paul and Clerk, Soil Microbiology and Biochemistry, 2007.
12. Paul, E.A. (Ed.). Soil Microbiology, Ecology and Biochemistry, 3rd edition, Academic Press, 2007.
13. Pepper, I.L. and Gerba, C.P. Environmental Microbiology – A Laboratory Manual, 2nd edition, Elsevier Academic Press, 2005.
14. Rao, N. S. Subba, Soil Microbiology, 4th edition, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, 2008.
15. Thakur, I.S. Environmental Biotechnology – Basic concepts and Applications, I.K. International, 2006.
16. Varma A., Oelmuller R. Advanced Techniques in Soil Microbiology, Springer (India) Pvt. Ltd, 2007.

L	T	P	C
3	-	-	3

Course Code	**7SL409ME27**
Course Title	**Microbiome Health and Disease**

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Understand the interaction between diet, the microbiome, and the host

CO2 Analyze the role of these interactions in host health and disease

CO3 Evaluate the acquired information to solve research questions and analyze case studies related to the topic

CO4 Development of novel therapeutics via manipulation of microbiome.

Syllabus: **Teaching Hours:45**

Unit 1: Introduction to Microbiome 8 Hours

Definition and components of the microbiome (bacteria, viruses, fungi, etc.); Microbial diversity and its importance in human health, Milestones in microbiome research; Methodologies in Studying the Microbiome; Challenges and advancements in microbiome analysis.

Unit 2: Microbiome and Human Health 7 Hours

Human Microbiome and Nutrition; role in Skin, Digestive system, Respiratory system, Urinary system, Reproductive system; Role during pregnancy; Gut-brain axis; Psych biotics

Unit 3: Factors Influencing the Microbiome 8 Hours

Influence of diet composition, dietary patterns, and food habits on the microbiome; Effects of exercise, stress, sleep, and other lifestyle factors on microbial diversity; Impact of environmental factors; Medical interventions.

Unit 4: Microbiome Dysbiosis and Disease 8 Hours

Disruptions in Microbial Balance; Alterations in microbiome composition and function; Dysbiosis-associated conditions; Infectious Diseases and Microbiome; Cancer and Chronic Diseases and Microbiome; Dysbiosis and Immune response.

Unit 5: Microbiome, Mycobiome and Virome interaction 7 Hours

Human Virome and host interaction; Microbiome – Mycobiome interaction; Microbiome – Virome Interaction, Bacteriome-Mycobiome-Virome interaction

Unit 6: Therapeutic Interventions and Applications 7 Hours

Probiotics, prebiotics, Postbiotics and their mechanisms of action in promoting a healthy microbiome; Sporulating and anaerobic microbes as potential probiotics; Clinical applications; Phage Therapy; Exploration of novel therapeutic avenues, including microbial-based drugs and engineered microbiota; Ethical considerations, regulatory challenges.

References:

1. Almand, E.A., Moore, M.D. and Jaykus, L.-A. (2017) 'Virus-Bacteria Interactions: An Emerging Topic in Human Infection', Viruses, 9(3), p. 58. Available at: https://doi.org/10.3390/v9030058.
2. Douglas, A.E. (2018) Fundamentals of Microbiome Science. Princeton University Press. https://doi.org/10.1515/9781400889822.
3. Handley, S.A. (2016) 'The virome: A missing component of biological interaction networks in health and disease', Genome Medicine, 8(1). Available at: https://doi.org/10.1186/s13073-016-0287-y.
4. Microbiome, Immunity, Digestive Health and Nutrition (2022). Elsevier. https://doi.org/10.1016/C2019-0-04103-9.
5. Microbiome Therapeutics (2023). Elsevier. Available at: https://doi.org/10.1016/C2021-0-01533-9.
6. Parks, D. (no date) Microbiomes: Health and the Environment MAVS OPEN PRESS ARLINGTON.
7. Santus, W., Devlin, J.R. and Behnsen, J. (2021) 'Crossing Kingdoms: How the Mycobiota and Fungal-Bacterial Interactions Impact Host Health and Disease', Infection and Immunity, 89(4). https://doi.org/10.1128/IAI.00648-20.
8. Genevieve Dable-Tupas, Rohini Karunakaran, Peter Paul C Lim, Maria Catherine B Otero. Human Microbiome Drug Targets Modern Approaches in Disease Management, 2024; ISBN: 9780443154355

L	T	P	C
3	-	-	3

Course Code	**7SL215ME27**
Course Title	**Structural Biology and Drug Discovery**

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Understand the architecture and building blocks of proteins, evaluate protein folds

CO2 Understand the protein folding and misfolding and the thermodynamic concepts of protein

CO3 Apply structure to function

CO4 Analyse the structure and function of membranes

CO5 Evaluate the macromolecular complexes and their biological complexity

Syllabus: **Teaching Hours:45**

Unit 1: Introduction **7 hours**

Overview of structural biology - Levels of structures in biological macromolecules; non-covalent forces determining biopolymer structure, principals of minimization of conformational energy.

Unit 2: Protein Structure **8 hours**

Proteins primary, secondary and tertiary structures - Structural implications of the peptide bond; Ramachandran Plot; Structural classification of proteins, structural motifs, profiles and protein families; Methods and techniques for study of protein structure and its perturbations by using X pray crystallography, electron microscopy, NMR techniques, Atomic force microscopy and cryo-EM.

Unit 3: Protein Folding **7 hours**

Folding in vivo and in vitro; protein stability, thermodynamics, and kinetics; Effect of various factors on folding; Folding intermediates- kinetic, equilibrium and molten globule intermediates; Techniques for studying the structure and folding of proteins; chaperones, peptidyl prolyl isomerase (PPI), Protein disulfide isomerase (PDI); Comparison of the structure and stability of proteins of mesophilic and extremophilic origin.

Unit 4: Biomolecular Interactions **7 hours**

Molecular recognition, supramolecular interactions, Protein-protein interactions, and their importance. Protein structure, protein crosslinking and oligomerization and its relevance in disease; Therapeutic approaches.

Unit 5: Techniques that detect protein-nucleic acid interaction **8 hours**

Structural elements of DNA and RNA; nucleic acid-protein complexes and the functional importance of protein-nucleic acid interactions; Protein-micromolecular interaction Therapeutic approaches that target structural elements of protein-nucleic acid interaction relevant to cellular pathophysiology

Unit 6: Membrane Structure **8 hours**

Lipid structure and their organization; Comparison between different membrane models; carrier transport, ion transport, active and passive transport, ion pumps, water transport, use of liposomes for membrane models and drug delivery systems. Drug treatment strategy that targets various membrane transport relevant to different kind of diseases.

References:

1. Central Drugs Standard Control Organization Http://CDSCO.NIC.IN/
2. Http://WWW.Patentoffice.NIC.IN/
3. WWW.OECD.ORG/DATAOECD/9/11/33663321.PDF
4. Http://WWW.FDA.GOV/FDAC/Special/Testtubetopatient/Studies. Html

5. Ranjit Kumar, Research Methodology- A Step-By-Step Guide for Beginners, Pearson Education, Delhi. 2006.
6. Trochim, William M.K., 2/E, Research Methods, Biztantra, Dreamtech Press, New Delhi, 2003.
7. Montgomery, Douglas C. 5/E, Design and Analysis of Experiments, Wiley India, 2007.
8. Kothari, C.K., 2/E, Research Methodology- Methods and Techniques, New Age International, New Delhi, 2004.
9. Besterfield, Dale H. 3/E, Total Quality Management, Pearson Education, New Delhi, 2005.
10. Scientific Communication- An introduction https://doi.org/10.1142/11541 | March 2020, pages 276
11. Science communication: A practical Gui
12. de for scientists, Laura Bowater, Kay Yeoman, ISBN: 978-1-118-40666-3 October 2012 Wiley-Blackwell 384 Pages;
13. https://www.wiley.com/en-us/Science+Communication%3A+A+Practical+Guide+for+Scientists-p-9781118406663
14. Structural Biology and drug discovery, method techniques and practices edited by Jean Paul Renaud, Wiley March 2020.
15. Structure based drug discovery, https://link.springer.com/book/10.1007/978-1-61779-520-6

Elective Courses III

L	T	P	C
3	-	-	3

Course Code	**7SL216ME27**
Course Title	**Molecular Medicine**

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Understand the basics introduction of molecular medicine

CO2 Analysis of the disease specific pathological mechanism and target for medicinal approach

CO3 Apply the methods to characterize therapeutic effects of medicine

CO4 Validating the molecular diagnosis of the disease

Syllabus: **Teaching Hours:45**

Unit 1: Introduction to Molecular Medicine 7 hours

Fundamental aspects of molecular medicine genetic mutation and repair. single nucleotide polymorphism of gene and biological consequences. General strategy and Fundamental aspects of infectious vs non-infectious diseases and acute and chronic disease progression. Role of biological environmental impact in various major diseases.

Unit 2: Cell signaling events and small molecule blocker 7 hours

Introduction of intracellular and extracellular signaling pathway. Role of Receptors and adaptor protein in cell signaling. Role of genetic mutation and mutant protein in cell signaling defect and associated diseases. Design of small molecule inhibitors and other strategies to counter balance the genetic and protein mutation restoring cellular physiology.

Unit 3: Pathophysiological spectrum of various diseases 8 hours

Discussing various factors including genetic, SNPS, protein mutation, cell signaling and endothelial disfunction etc. for the trigger of cancer, diabetes, neurodegeneration, coronary artery disease and others.

Unit 4: Effect of medicine in biological system 6 hours

Basic ideas on biodistribution and pharmacokinetic of medicine, toxicity and hepatic metabolism of the oral medicine, various types of formulation of the medicine, biotechnology drugs such as antibody, protein and other forms of drug conjugate used as formulation for drug delivery

Unit 5: Molecular Diagnosis 8 hours

Brief description for application of to various analytical tools to characterize the drug like molecules. Use of laboratory-based cell biological markers, prognostic marker for the validation of drug effect on biological molecule such as DNA sequencing analysis, mutation analysis, PCR, gene therapy, Si-RNA knockdown, western blot, cell viability assay etc.

Unit 6: Drug Design and Computational Drug Discovery Approach 9 hours

Rational drug design to targets that is relevant to various diseases such as cancer, diabetes, neuronal disorders, psychological complications, osteoporosis, endocrine disorders, and others etc. Structure activity relationship. Application of bio-informatics method and in silico application to drug design and virtual screening of drug against a disease specific target gene/protein.

References:

1. Alberts B, Johnson A, Lewis J, Raff M, Roberts K and Walter P, "Molecular Biology of the Cell", Fifth Edition, Garland Publishing Inc. 2008.

2. Molecular Medicine Book by Robert M. White (Author), David W. Brown (Author), Steven A. Williams. ISBN-10, 1594250332.
3. Introduction to Molecular Medicine by D. W. Ross, publisher Springer, 9th march 2013.
4. Molecular Medicine is the application of genetic or DNA-based knowledge to the modern practice of medicine. *Molecular Medicine* by R J Trent, 22nd August 2022.
5. *Philosophy of Molecular Medicine: Foundational Issues in Theory and Practice* aims at a systematic investigation of a number of foundational issues in the field of molecular medicine. Routledge publication, 1st edition (18 Dec. 2020).
6. Textbook Of Biochemistry, Biotechnology, Allied And Molecular Medicine by Gp Talwar, Seyed E Hasnain , 4th edition. November 2015 publication.

L	T	P	C
3	-	-	3

Course Code	**7SL202ME27**
Course Title	**Cancer Biology**

Course Learning Outcomes (CLO):

At the end of the course, students will be able to-

CO1 Describe and appraise the fundamentals of cellular processes involving molecular genetic basis of multistep process of carcinogenesis Illustrate mechanisms of physical, biological, and chemical cancer-causing agents as well as spontaneous cancer onset in terms of role of oncogenes and tumour suppressor genes, deregulation of cell cycle and differentiation in cancer cells.

CO2 Articulate host-environment interactions including susceptibility factors in cancer predisposition; cancer classification systems; principles of cancer diagnosis, prognosis, and response to therapy and management in the laboratory.

CO3 Demonstrate understanding of cancer control for disease-free, relapse-free, and metastasis-free longer survival using knowledge of molecular players and factors governing cancer spread from primary sites, metastasis cascade, and invasion.

Syllabus: **Teaching Hours: 45**

Unit 1: Introduction to Cancer Biology **6 Hours**

History of cancer and various theories of Cancer etiology, Warning signs of cancer; Types of cancer; cancer classification systems: Epidemiology; Updates in hallmarks of cancer cells including; Self-sufficiency in growth signals, insensitivity to growth suppressive signals, evading programmed cell death, replicative immortality, sustained angiogenesis, invasion and metastasis, reprogramming energy metabolism, evading immune destruction, tumor promoting inflammation, genomic instability, and others

Unit 2: Molecular Cell Biology of Cancer **8 Hours**

Proto-oncogenes and Oncogenes, Mechanisms of inactivation of proto-oncogenes and affected cellular pathways; Tumor suppressor genes, two-hit theory, mi-RNA and other regulators of cellular pathways and cancer, modulation of growth factors, receptors, signal transduction, Cancer Stem cells, Biology, and implications; Apoptosis, Autophagy, Necroptosis, Ferroptosis and pyroptosis.

Unit 3: Cancer Genetics, Cytogenetics and Genomics: **10 Hours**

Constitutional and Acquired Genetic Determinants of Cancer; Genetic Predisposition to Cancer; Hereditary cancer syndromes and Familial Cancers; Molecular pathogenesis of acquired chromosomal aberrations, fusion genes, Common techniques for analysis of alterations in chromosomes and DNA, Techniques for analysis of alterations in chromosomes and DNA.

Unit 4: Principles of Carcinogenesis **8 Hours**

Physical, Chemical and Biological Carcinogenesis, Genotoxic and non-genotoxic carcinogens, Cancer Metabolism and Targets of Carcinogenesis, Molecular mechanism of Carcinogenesis. Cancer risk factors and differential susceptibility, IARC and WHO and OECD guidelines.

Unit 5: Cancer Metastasis **8 Hours**

Metastatic cascade; Basement Membrane disruption; Three-step theory of Invasion; Heterogeneity of metastatic phenotype; Epidermal Mesenchymal Transition, Molecular signatures and organ preference in metastasis and Angiogenesis

Unit 6: Cancer Biomarkers and Therapeutics **5 Hours**

Classical and novel strategies for cancer treatment; Tumor markers for cancer diagnosis, prognosis, and therapy decisions; Cancer Immunology and therapeutic interventions, Humanized /Chimeric antibodies in cancer diagnosis and treatment, Targeted drug delivery and drug delivery systems, Animal models for cancer, Cancer vaccine, Clinical trials, Immune cell therapies, Gene Therapy, survival and response monitoring, targeted therapy with examples of clinical importance, personalized medicine

References:
1. Weinberg R., Biology of Cancer, Garland Science, June, 2010
2. D. Liebler, Proteomics in cancer research, 2004
3. David M. Terrian, Cancer cell signalling, Methods, and protocols, Volum 218 (Methods in Molecular Biology), 2003.
4. Strachan Tom and Read Andrew P. (2010) Human Molecular Genetics, 4th Edition, Garland Science (Taylor and Francis Group), London and New York
5. K.L. Rudolph, Telomeres and Telomerase in ageing, disease, and cancer, 2008.
6. Maly B.W.J., Virology: A practical approach, IRL Press, Oxford, 1987.
7. Dunmock N.J and Primrose, S.B., Introduction to modern Virology, Blackwell Scientific Publications. Oxford, 1988.
8. Knowles, M.A., Selby P., An Introduction to the Cellular and Molecular Biology of Cancer, Oxford Medical publications, 2005.
9. Vincent, T. De Vita, Lawrence T. S., Rosenberg, S. A., Cancer: Principles & Practice of Oncology, 10th Edition, Lippincot, 2011
10. http://atlasgeneticsoncology.org
11. http://cgap.nci.nih.gov/Chromosomes/Mitelman
12. http://www.humanvariomeproject.org
13. https://www.genome.gov/hapmap

L	T	P	C
3	-	-	3

Course Code	**7SL411ME27**
Course Title	**Food and Dairy Microbiology**

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

CO1 Learn fundamentals associated with microbiology of dairy and non-dairy foods
CO2 Learn principles of food preservation
CO3 Learn role of microbes in food spoilage, and risks imposed by food-borne pathogens

Syllabus: **Teaching hours: 45**

Unit 1: The Scope of Food Microbiology 7 Hours
Microorganisms in foods; Microbial growth response in the food environment; Intrinsic and extrinsic factors affecting growth and survival of microorganisms in foods

Unit 2: Microbiology of Food Preservation 8 Hours
Heat processing; Irradiation; Ultrasonication; High-pressure processing; Low-temperature storage; Chemical preservatives; Modification of atmosphere; Control of water activity

Unit 3: Dairy Microbiology 7 Hours
Milk and milk processing; Microbiology of raw milk and market milk; Fermented milks; Therapeutic milks; Microbiology of fermented milk products

Unit 4: Microbes as process organisms in fermentation industry 7 Hours
Starter cultures; Probiotics, prebiotics, synbiotics, postbiotics, and parabiotics; Production and delivery of probiotics; Nutraceuticals of microbial origin

Unit 5: Food Microbiology and Public Health 8 Hours
Microbial food spoilage; Bacterial and non-bacterial agents of foodborne illness; Detection of pathogens in food samples

Unit 6: Quality Control in Food and Dairy Industry 8 Hours
Quality Control in Food and Dairy Industry: The Hazard Analysis and Critical Control Point (HACCP) Concept; Relevant FSSAI and The Codex Alimentarius Commission (CAC) regulations; Hygiene in food/milk product manufacture

References:
1 Adams and Moss (2007). Food Microbiology. New Age International Publishers
2 Richard Robinson (Ed) (2002). Dairy Microbiology Handbook: The Microbiology of Milk and Milk Products, 3rd Edition. Wiley. ISBN: 978-0-471-38596-7
3 Ralph Early (1997) (Ed). The Technology of Dairy Products. Springer. ISBN: 978-0-7514-0344-2.
4 Bibek Ra
5 y and Arun Bhunia (2025). Fundamental Food Microbiology. Sixth Edition. CRC Press.
6 MP Doyle, Diez-Gonalez, and Colin Hill (2019). Food Microbiology: Fundamentals and Frontiers. Fifth edition. ASM Press.

SEMESTER-IV

Elective Course

L	T	P	C
-	-	-	15

Course Code	**7SL902ME27**
Course Title	**Dissertation**

Course Learning Outcomes (CLO):
At the end of the course, students will be able to-

CO1 Develop understanding in the field of scientific research at the academic as well as industrial sector. This will students to identify scientific problems and design proposals to address and

implement ideas. This enables them to communicate the same to a greater audience.

This will benefit the students to perform well in their job interviews and to design their CV which can evoke interest in the employers to know more about the candidate.

Outline:
The students have to carry out their dissertation work. They have to perform wet lab experimentation on the topic of project assigned to them. The Viva will be conducted as interim presentation as well as final presentations, where the students have to defend their dissertation work

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Course Code	**7SL903ME27**
Course Title	**Internship**

Outline:
The students will be deputed to industry/academic institutes/laboratories have undertake training to enhance their skills in order to improve their employability in the field of interest. The students will have a guide allocated at the host institute and have to present their progress of training in the form of interim presentation. They will be submitting a comprehensive report as well as well as a final presentation, comprising of the training undertaken by them.