HSNC UNIVERSITY, MUMBAI

Board of Faculty of Science & Technology

Board of Studies in the Subjects of Microbiology

1) Name of Chairperson/Co-Chairperson/Coordinator:-

a) Dr. Sejal Rathod, Assistant Professor and Head, Department of Microbiology, K. C. college, HSNC University Churchgate, Mumbai –400 020. Email ID- sejal.rathod@kccollege.edu.in, Mobile no- 9930082028

2) Two to five teachers each having minimum five years teaching experience amongst the full time teachers of the Departments, in the relevant subject.
a) **Dr. Pratibha Shah**, Assistant Professor, Department of Microbiology, K. C. college, HSNC University Churchgate, Mumbai – 400 020. Email ID pratibha.shah@kccollege.edu.in, Mobile No- 9773321760
b) **Mrs. Rajitha Satish**, Assistant Professor, Assistant Professor, Department of Microbiology, K. C. college, HSNC University Churchgate, Mumbai – 400 020. Email ID rajitha.satish@kccollege.edu.in, Mobile No- 9833716190
c) **Ms. AminaDholkawala ,** Assistant Professor, Department of Microbiology, K. C. college, HSNC University Churchgate, Mumbai – 400 020. Email ID amina.dholkawala@kccollege.edu.in, Mobile No- 7208724194

3) One Professor / Associate Professor from other Universities or professor / Associate Professor from colleges managed by Parent Body;
a) **Dr Bela Nabar**, Associate Professor, HOD of Microbiology, CHM College, Ulhasnagar. Email ID belamsn23@gmail.com **, Mobile No-** 9322760417

b) Dr. S. Raut, Assistant Professor, Department of Microbiology, Bhavan's College, Mumbai Email ID svrmicro@yahoo.co.in **, Mobile No-** 9869053676

4) Four external experts from Industry / Research / eminent scholar in the field relevant to the subject nominated by the Parent Body;

a) Mrs. PrabhaPadmanabha, ex Associate Professor, Department of Microbiology, K. C. college Email ID prabhapadmanabha@hotmail.com, **Mobile No**-9820860049

b) **Dr. SahayogJamdar,** Scientific Officer G, Food and Technology Division, BARC, Trombay, Mumbai Email ID snjam2@gmail.com, **Mobile No**-2225595375

c) **Dr. MehulRajpurkar**, Regional Medico Marketing Manager, SRL Diagnostics Email ID mehul.rajpurkar@gmail.com, **Mobile No-** 9819107505

d) **Dr. Surekha Zingde,** Former Dy. Director, Cancer research institute, ACTREC, Tata Memorial Centre Kharghar, Email ID surekha.zingde@gmail.com, **Mobile No-**9820633284

5) Top rankers of the Final Year Graduate and Final Year Post Graduate examination of previous year of the concerned subject as invitee members for discussions on framing or revision of syllabus of that subject or group of subjects for one year.

a) **Ms. Uzma Shaikh** (undergraduate student 18-19) Email Id uzma25.shaikh@gmail.com; Mobile no- 9082811707

b) **Ms. Soni Gupta** (post graduate student 18-19). Email sonigupta445@gmail.com : Mobile no- 9167147185

HSNC University Mumbai

(2020-2021)

Ordinances and Regulations

With Respect to

Choice Based Credit System

(CBCS)

For the Programmes Under

The Faculty of Science and Technology

For the Course

Microbiology

Curriculum – First Year Postgraduate Programmes

Semester-I and Semester -II

2020-2021

Section D

Microbiology

Part 1- Preamble

This two- year M. Sc. programme is designed by experts from Academia, Industry and research institution to develop skilled Microbiologists who can progress to diverse fields of microbiological interests that include industry, research, teaching, medical science and entrepreneurship.

The course is aimed at adding to the knowledge base of Microbiology graduates through significant inputs of latest information on the subject. It also envisages that the students read original research publications and develop the ability of critical evaluation of the study. Development of communication skills - written and spoken - as well as laboratory work and team work, creativity, planning and execution are also a major objective of this programme.

In the core courses, the students study the basics of Microbiology along with the basics of subjects allied to and useful in Microbiology. The specializations include topics on various fields of Cell Biology, Genetics, Molecular Biology, Biochemistry, Medical Microbiology and Immunology in the first year of the programme.

Students are required to undergo a training program and complete online courses as a part of their continuous internal evaluation. Students will also have to learn literature survey, writing a scientific report, and research proposal for their continuous evaluation. This will prepare them well for the Research Project in Semester IV.

The student has to take training in the Industry for a period of at least three weeks in the vacation period after Semester – II. The student should study Microbiological aspects in the Industry and submit its report. Students are also required to compulsorily undertake an educational tour organized by the Department in each year (M. Sc. I and M. Sc. II) to various places of Microbiological interest and submit a Report.

1. Course Objectives:

Semester I

MMB- 101:Virology and Cell Biology I

- Understand the architecture and replication of bacteriophages
- Understand the structure and function of the Cell membrane
- Understand the structure and function of the single membrane organelles
- Understand the transport function of the membrane
- Understand and apply microscopic techniques to the study of cell structure

MMB-102: Genetics and Molecular Biology I

- Study the structure and variation in chromosomal structure and human cytogenetics
- Study the Drosophila development and population genetics
- Learn Metagenomics, proteomics and epigenetics
- Understand the Cytoplasmic Inheritance & Chromosomal Rearrangements

MMB-103: Microbial Biochemistry I

- Study the structure and function of organic molecules
- Study the protein structure, folding and its regulation
- Learn the role of membrane in transport of biomolecules
- Understand the integration of metabolic pathways and channelling of metabolic fuels.
-

MMB-104: Medical Microbiology and Immunology I

- To learn the different methods of testing antimicrobials activity and drug resistant organisms.
- To learn principles of epidemiology and different ways of public health surveillance
- To understand the threat of antibiotic resistance and different methods of testing drug resistant organism
- To learn the Clinical lab practices in bacteriology like QC and AST
- To study ‘Emerging and re-emerging diseases’ in India and worldwide.
- To learn mechanism andrecent advances of innate immunity, immune tolerance and regulation.
- To understand the Human gut microbiome project and its importance.

Semester II

MMB-201: Virology & Cell Biology II

- Understand the structure and replication of Plant viruses and viroids
- Understand the structure and replication of animal viruses causing significant diseases.
- Study virus evolution and the emergence of new and re-emerging animal viruses affecting human health.
- Understand Cell Division and Cell cycle
- Understanding the link between faulty cell cycle control systems and cancer
- Study cell to cell communication and signalling

MMB-202: Genetics and Molecular Biology II

- Learn Rational mutagenesis and molecular tools for genetics
- Study the Genetic exchange and recombination
- UnderstandTransposons and cancer genetics
- Study Social, legal and Ethical issues of genetic technology.

MMB-203: Biochemistry II

- Learn enzyme kinetics, regulation and mechanism of enzyme action
- Study the metabolism of one carbon compounds and aromatic compounds
- Understand signalling systems and stress responses in bacteria
- Study gene regulation in prokaryotes and eukaryotes.

MMB-204: Medical Microbiology and Immunology II

- To learn about the different types of immunodeficiency and autoimmune disorders and their modes of treatment
- To understand the concepts of applied immunology such as transplantation and tumor immunology
- To study different experimental techniques useful in immunological diagnosis
- To learn about recent advances in diagnostics methods.
- To learn the Good manufacturing practices concerned with quality control and production of quality drugs and products in pharmaceutical industry

2. Process adopted for curriculum designing:

The curriculum was designed in a stepwise manner, firstly on the basis of feedback obtained from department teachers and students. Later several meetings were conducted with representatives from academia, industries and research institutions to assure that the syllabus is enriched in all the aspects.

3. Salient features, how it has been made more relevant.

The syllabus is designed with the aim to prepare students for competitive exams, research and industry. Students will gain extensive knowledge about virology, cell biology, genetics, biochemistry and Medical microbiology to better prepare them for various career opportunities.

4. Learning Outcomes.

Our program is designed in a way to educate the learner about various fields of Microbiology like Virology, Cell biology, Genetics, Biochemistry and Medical Microbiology. The program would help the learner to apply their skills to summarize, analyze, and instill problem solving approach in the latest developments and innovations in the future.

5. Input from stakeholders

Inputs for industrial, academic and research experts has shaped the syllabus to be extensive and comprehensive. Missing links for various topics have been added along recent advances in various to enable a complete understanding of students.

Part 2- The Scheme of Teaching and Examination is as under:

Semester – I
Summary

Sr. No.	Choice Based Credit System			Subject Code	Remarks
1	Core Course (**Biotechnology**)			PS-FMB 101,PS-FMB 102, PS-FMB 103,PS- FMB 104 PS-FMB 1P1, PS-FMB 1P2	
2	Elective Course	Discipline Specific Elective (DSE) Course			
		2.1	Interdisciplinary Specific Elective (IDSE) Course		
		2.2	Dissertation/Project		
		2.3	Generic Elective (GE) Course		
3	Ability Enhancement Courses (AEC)				
4	Skill Enhancement Courses (SEC)				

First Year Semester I Internal and External Detailed Evaluation Scheme

Sr. No.	Subject Code	Subject Title	Periods Per Week						Internals				Total Marks
			Units	S.L.	L	T	P	Credit	S.L.E.	CT+AT= 15+5	PA	SEE	
1	PS-FMB 101	Virology &Cell Biology- I	4	20% *	4	0	0	2	10	20	10	60	100
2	PS-FMB 102	Genetics and Molecular Biology-I	4	20% *	4	0	0	2	10	20	10	60	100
3	PS-FMB 103	Microbial Biochemistry-I	4	20% *	4	0	0	2	10	20	10	60	100
4	PS-FMB 104	Medical Microbiology-I	4	20% *	4	0	0	2	10	20	10	60	100
5	PS-FMB 1P1	Practicals Based PS-FMB -101 + Practicals Based PS-FMB -102			0		6	2				100 (80 +20)	100
6	PS-FMB 1P2	Practicals Based PS-FMB 103 + Practicals Based PS-FMB 104			0		6	2				100 (80 +20)	100
	Total Hours / Credit							20	Total Marks				600

***One to two lectures to be taken for CONTINUOUS self -learning Evaluation.**

First Year Semester I - Units – Topics – Teaching Hours

S. N	Subject Code	Subject Unit Title		Hours/Lectures	Total No. of hours/lectures	Credit	Total Marks
1	PS-FMB -101	1	General Virology	15	60 L	2	100 (60+40)
		2	Bacteriophages	15			
		3	Cell Biology (Membrane structure and transport)	15			
		4	Cell Biology (Respiratory & Photosynthetic organelle)	15			
2	PS-FMB -102	1	Genetic exchange and recombination	15	60 L	2	100 (60+40)
		2	Drosophila development and population genetics	15			
		3	Metagenomics, proteomics and epigenetics	15			
		4	Cytoplasmic Inheritance & Chromosomal Rearrangements	15			
3	PS-FMB -103	1	Chemical reactivity, Minerals and Glycobiology	15	60 L	2	100 (60+40)
		2	Biomolecules	15			
		3	Nucleic acids and Transport of biomolecules	15			
		4	Metabolism, Metabolic Fuels and Endocrinology	15			
4	PS-FMB -104	1	Epidemiology of infectious diseases and Clinical Bacteriology	15	60 L	2	100 (60+40)
		2	Emerging and Re-emerging Diseases.	15			
		3	Tolerance and Regulation of Immune system and Hypersensitivity	15			
		4	Immunobiology	15			
5	PS-FMB -1P1	1	Practicals based on PS-FMB -101	3	60x2= 120 lectures per batch	2	100 (80+10 +10)
		2	Practicals based on PS-FMB -102	3			

9	PS-FMB - 1P2	1	Practicals based on PS-FMB -103	3	60x2= 120 lectures per batch	2	100 (80+10 +10)
		2	Practicals based on PS-FMB -104	3			
			TOTAL			20	600

- **Lecture Duration – 45 Minutes = 0 .75 Hours. (45 Lectures equivalent to 33.75 hours)**
- **One Credit =16.87 hours equivalent to 17 Hours**

L: Lecture: Tutorials P: Practical Ct-Core Theory, Cp-Core Practical, SLE- Self learning evaluation CT-Commutative Test, SEE- Semester End Examination , PA-Project Assessment, AT- Attendance

Part -3 Detailed Scheme Theory

Curriculum Topics along with Self-Learning topics - to be covered, through self-learning mode along with the respective Unit. Evaluation of self-learning topics to be undertaken before the concluding lecture instructions of the respective UNIT

Course Code: PS-FMB -101 (Virology & Cell Biology- I)

Unit	Topic	Credits	Lectures	References
1	**General Virology:**	01	15	
	1.1 Structure of viruses 1.1.1. Enveloped and non-enveloped viruses 1.1.2. Structural proteins and Capsid symmetries 1.1.3. Viral genomic organization and replication 1.1.4. Protein nucleic acid interactions and genome packaging 1.1.5. ICTV nomenclature and classification of viruses		07	Teri Shors International Congress on Taxonomy of Viruses
	1.2Cultivationandenumerationof viruses: Growth of viruses in – 1.2.1. *In ovo*: using embryonated chicken eggs 1.2.2. *In vivo*: using experimental animals 1.2.3. *Ex vivo / In vitro* : using various cell cultures - primary and secondary cell lines, suspension cell cultures and monolayer cell cultures 1.2.4. Plants and plant cell cultures		06	Wagner
	1.3 - Virus related structures – viroids, prions and plant satellite viruses		02	Teri Shors
2	**Bacteriophages:**	01	15	
	2.1 Bacteriophages: General properties of phages, properties of phage infected Bacterial cultures, Specificity of Phage Infection		03	Teri Shors
	2.2*E. coli* Phage T7: Properties of T7 DNA, Genetic organization, the T7growth cycle, Replication of T7 DNA- can be removed		05	Edward A. Birge
	2.3*E.coli* Phage Lambda: Organization of the Lambda genes, Growth Cycle, Regulation of transcription of Lambda phage.		05	
	2.4 Phage therapy for control of bacterial poultry diseases and Mycobacteriophages		02	Azimi T
3	**Cell Biology (Membrane structure and transport)**	01	15	
	3.1 Cell membrane structure: Lipid bilayer, membrane proteins, Spectrins, Glycophorin, Multipass membrane proteins Bacteriorhodopsin		03	Albert, Johnson

	3.2 Cell Junctions and cell adhesion: Anchoring, adherence junctions, Desmosomes, Gap junctions, cell-cell adhesion, Cadherins		03	Lodish
	3.3 Intracellular Compartments and protein sorting: Compartmentalization of cells, transport of molecules between the nucleus and cytosol, peroxisomes, Endoplasmic reticulum, transport of proteins into mitochondria and chloroplasts		05	Lipowsky and Sackmann. Karp G.7thEd
	3.4 Intracellular vesicular traffic: Endocytosis, exocytosis, transport from the ER through the Golgi apparatus		04	
4	**Cell Biology (Respiratory & Photosynthetic organelle)**	01	15	
	4.1 Mitochondria: Structure, electron-transport chains and proton pump		02	Albert, Johnson
	4.2 Chloroplasts: Structure, energy capture from sunlight		02	
	4.3 Cytoskeleton: Cytoskeletal filaments, Microtubules, Actin regulation, molecular motors, cell behavior.		05	
	4.4 Cell study: Study of cells under the microscope, Phase contrast, Fluorescence microscopy, Confocal microscopy, Electron Microscopy, Atomic force microscopy, TIRF microscopy.		06	Cooper,G

Self-Learning topics (Unit wise)

Unit	**Topics**
1.1.1, 1.1.2	Enveloped virus, Structural proteins and capsid symmetry
1.3	Prions
2.4	Phage therapy for control of bacterial poultry diseases and Mycobacteriophages
3.2	Cell Junctions and cell adhesion
4.3	Cytoskeleton

Online Resources
Online module: Enveloped virus, structural proteins and capsid symmetry https://www.youtube.com/watch?v=jY3axuAm2AA&feature=youtu.be https://www.classcentral.com/course/virology-952 **Online module**: Prions https://www.coursera.org/lecture/advanced-neurobiology1/3-3-7-prion-diseases-PcOq7 **Online module:** Phage therapy for control of bacterial poultry diseases and Mycobacteriophages https://onlinecourses.swayam2.ac.in/cec20_bt15/preview **Online module:** Cell Junctions and cell adhesion https://www.youtube.com/watch?v=ElDO-mnswlM https://nptel.ac.in/courses/102/103/102103012/ (https://www.swayamprabha.gov.in/) **Online module:** Cytoskeleton https://www.youtube.com/watch?v=jnoJqDZtf3E (https://www.swayamprabha.gov.in/) https://nptel.ac.in/courses/102/103/102103012/

PS-FMB **-102 (Genetics and Molecular Biology)**

Unit	Topic	Credits	Lectures	References
1	**Genetic exchange and recombination**	01	15	Larry Snyder 3rd edition
	1.1 Conjugation: 1.1.1 Overview, Classification of self-transmissible plasmids, 1.1.2 Mechanism of DNA transfer during Conjugation in Gram negative bacteria, Chromosome transfer by plasmids, Formation of Hfr strains, transfer & mobilization of chromosomal DNA by integrated plasmids, prime factors, 1.1.3 Transfer system of Gram-positive bacteria-Plasmid pheromones		05	
	1.2 Transformation**:** 1.2.1 Development of Competence in Gram positive bacteria and Gram- negative bacteria, competence based on type IV secretion systems. Regulation of competence in Bacillus subtilis-Competence pheromones. 1.2.2 Role of natural transformation- Nutrition, repair, recombination, Importance of natural transformation for forward and reverse genetics. 1.2.3 Artificially induced competence- Calcium ion induction, transformation by plasmids, transfection by phage DNA, transformation of cells with chromosomal genes, Electroporation.		03	
	1.3 Transduction: 1.3.1 P1 as model of generalized transduction 1.3.2 Specialized transduction- λ phage as model system, LFT & HFT lysate, Making merodiploids with specialized transducing phage.		02	
	1.4 Homologus recombination at molecular level 1.4.1Models for Homologous recombination Homologues recombination protein machines Homologous recombination in *E.coli* (Rec BCD pathway), 1.4.2 Homologous recombination in eukaryotes-Mating type switching, Site Specific recombination		05	Watson
2	**Drosophila development and population genetics**	01	15	

	2.1 Drosophila developmental - Stages, Embryonic development, Maternal effect genes, segmentation genes, Homeotic genes		05	
	2.2 Population genetics 2.2.1 Genetic structure of population 1. Hardy-Weinberg Law 2. Genetic variation in space and time 3. Genetic variation in Natural population 4. Forces that change gene frequenciesin populations: i. Mutation, ii. Random genetic drift iii. Migration iv. Natural selection v. Balance between mutation and selection vi. Assertive mating vii. Inbreeding 2.2.2 Summary of the effects of evolutionary forces on the genetic structure of population The role of genetics in conservation Biology		10	iGenetics-Russell
3	**Metagenomics, proteomics and epigenetics**	01	15	
	3.1 Metagenomics 3.1.1 Comparative Genomics: finding Genes that make us human, recent changes in the human genome 3.1.2 Characterization of Gene amplification and deletions in microbiomeusing DNA microarrays (Representational Oligonucleotide Microarray Analysis (ROMA) 3.1.3 Functional genomics-DNA Microarray technology, Serial analysis of gene expression (SAGE)		07	C. David
	3.2 Proteomics 3.2.1 Separation and identification of proteins (2D PAGE, MALDI –TOF), Protein profiling (LC-MS), 3.2.1Protein interaction by Co-immunoprecipitation, protein tagging system, Protein Microarrays, Protein protein interaction Mapping (Two hybrid assay, TAP tag procedure)		06	
	3.3 Epigenetics 3.3.1 Definition, Model Systems for the Study of Epigenetics 3.3.2 Rregulation of chromatin structure through histone post-translational modifications and cova-lent modification of DNA		02	
4	**Cytoplasmic Inheritance & Chromosomal Rearrangements**		15	

	4.1 Cytoplasmic Inheritance (Organellar Genetics) 4.1.1 **Mitochondrial-DNA** i. Mitochondrial genome structure ii. Ancestral and derived mitochondrial genome iii. Mitochondrial DNA of Human, yeast and flowering plants iv. Endosymbiotic theory v. Mitochondrial DNA replication, transcription & translation vi. Codon usage in Mitochondria vii. Damage to Mitochondrial DNA and aging. viii. Evolution of Mitochondrial DNA ix. mt DNA analysis for study of evolutionary relationships 4.1.2 **Chloroplast DNA** i. Gene structure and organization ii.General features of replication, transcription and translation of cpDNA iii. Comparison of nuclear, eukaryotic, eubacterial, mitochondrial and chloroplast DNA iv. Examples of extra nuclear inheritance. Leaf Variegation, Poky mutant of Neurospora Yeast petite mutant, Human genetic diseases	01	10	Pierce 4th edition
	4.2 Chromosomal Rearrangements and effects on gene expression 4.2.1. Amplification and deletion of genes 4.2.2. Inversions that alter gene expression 4.2.3. Transpositions that alter gene i. Expression antigenic variation in Trypansomes ii. Mating type switching in yeast iii. Phase variation in Salmonella		05	

Self-Learning topics (Unit wise)

Sub- Unit	Topics
1.4.1	Homologous recombination
2.1	Drosophila development
3.2	Proteomics
4.1.1, 4.2.1	General features of mitochondrial and chloroplast DNA

Online Resource
Online module: Homologous recombination https://nptel.ac.in/courses/102/103/102103015/ Online module: Drosophila development https://nptel.ac.in/courses/104/108/104108056/(Mod-07 Lec-24) https://www.youtube.com/watch?v=LU6xHqcVfCQ Online module: Proteomics https://nptel.ac.in/courses/102/101/102101068/ Online module: General features of mitochondrial and chloroplast DNA https://www.youtube.com/watch?v=-GgROdV9vm8 (https://www.swayamprabha.gov.in/)

PS-FMB **-103 Microbial Biochemistry**

Unit	Topic	Credits	Lectures	References
1	**Chemical reactivity, Minerals and Glycobiology**		15	
	1.1 Overview of Types of Bonds Various units of expressing and inter-converting concentration of solutions: molarity, moles, normality, osmolarity, molality, mole fraction, Bronsted concept of conjugate acid –conjugate base pairs, ionization of solutions, pH, titration curves, buffers: preparation and action, Henderson-Hasselbalch equation, buffer capacity, polyproteic acids, amphoteric salts, ionic strengths.		05	Lehninger, Metzler Harper, Lehninger, Segel Irvin H. (1997). Biochemical Calculations.
	1.2 Minerals Calcium, Phosphorus and Iron distribution in the human body, digestion, absorption, utilization, transport, excretion, balance, deficiency, toxicity, sources, RDA. Calcium: Phosphorus ratio, Role of iron in prevention of anaemia. Iodine, Fluoride, Mg, Cu, Zn, Se, Manganese, Chromium and Molybdenum distribution in the human body, function, deficiency, toxicity and sources.		05	B.K. Sharma
	1.3 Overview of Monosaccharides, Disaccharides and Polysaccharides. Microbial polysaccharides and plant polysaccharides and their commercial applications. Glycoconjugates: Proteoglycans, Glycoproteins, and glycolipids (gangliosides and lipopolysaccharides) Carbohydrates as Informational Molecules: The Sugar Code.		05	Conn & Stumpf Nelson D. L. and Cox M. M. (2002) Lehninger's Principles of Biochemistry
2	**Biomolecules** .		15	
	2.1 Proteins – Structure of peptide bond, stability of formation of peptide bond, Ramachandran plot, Hierarchy of protein structure, folding, modification and degradation of proteins, molecular motors and the mechanical works of cells, common mechanisms of regulating protein function.		08	Lehninger, Conn & Stumpf Molecular cellular biology-Baltimore

	2.2 Lipids and sterols - Lipid classification, structure and function of lipids in membranes-glycerolipids, ether lipids, galactolipids, sulfolipids, lipids in archaebacteria, sphingolipids, terpenes, isoprenoids, steroids, cholesterol. Functions of lipids- signals, cofactors, pigments.		05	Lehninger, Gottschalk David White
	2.3 Vitamins and coenzymes – Structure, active forms and functions of water-soluble vitamins and their coenzyme forms (Niacin, Riboflavin, Pantothenic acid, Thiamine, Pyridoxal, Vitamin B12, Folic acid, Glutathione) Fat soluble vitamins (A, D, E, and K), Biochemical basis for deficiency symptoms.		02	Lehninger Conn & Stumpf
3	**Nucleic acids and Transport of biomolecules**–		15	
	3.1 Nucleic acid chemistry: Overview of nucleosides, nucleotides, phosphodiester linkages, tautomeric forms of bases and their implication in pairing of bases, Structure of DNA, its types and synthesis of nucleotides. Denaturation and reassociation of DNA, Tm value, Cot curves, Types and structure of RNAs – RNAs involved in protein synthesis (t-RNA, r-RNA, and m-RNA) and DNA replication, Regulatory RNAs and parasitic RNAs. Metabolic disorders caused due to catabolism of Nucleotides.		05	Conn &StumpfLehninger Harper
	3.2 Biological Membranes : Overview of Biological membranes (Prokaryotes and eukaryotes), transport- membrane dynamics, role of transporters in solute transport, Study of Glucose transport in cell and Chloride-bicarbonate exchanger of the erythrocyte membrane, Diseases caused due to mutations in membrane proteins, Role of membrane in Multi drug resistance and Energy transduction.		05	White, Lehninger Harper Stryer
	3.3 Protein transport: Overview of protein synthesis in prokaryotes and eukaryotes, Role of chaperones, cytosolic protein sorting, N-terminal signal peptides, extracellular protein secretion.		05	Brock, Harper
4	**Metabolism, Metabolic Fuels and**		15	

	Endocrinology			
	4.1 Introduction to Metabolomics		02	Lehninger Harper David White Stryer Hadley and Levine
	4.2 Metabolic pathways study at different levels of organization		03	
	4.3 The flux of metabolites in metabolic pathways must be regulated in a concerted manner		02	
	4.4 Supply of metabolic fuels		02	
	4.5 Endocrinology : Functions of hormones and their regulation. Chemical signalling - endocrine, paracrine, autocrine, intracrine and neuroendocrine mechanisms. Chemical classification of hormones, Hormone therapy. Hormone receptors - extracellular and intracellular, G proteins, G protein coupled receptors, second messengers - cAMP, cGMP, DAG, Ca^{2+}, NO.		06	

Self-Learning topics (Unit wise)

Sub- Unit	Topics
1.3	Overview of Monosaccharides, Disaccharides and Polysaccharides.
2.3	Vitamins and coenzymes
2.1	Protein folding
4.5	Functions of hormones

Online Resource
Online module: Overview of Monosaccharides, Disaccharides and Polysaccharides. https://www.youtube.com/watch?v=93ngcQHOixQ (https://www.swayamprabha.gov.in/)
Online module: Vitamins and coenzymes https://www.youtube.com/watch?v=VxtQPuXiMAA (https://www.swayamprabha.gov.in/)
Online module: Protein folding https://www.youtube.com/watch?v=h_ZPur9E_jg (https://www.swayamprabha.gov.in/)
Online module: Functions of hormones https://www.youtube.com/watch?v=pBKdfpF2es4 https://www.youtube.com/watch?v=XX11BaP4m8I (https://www.swayamprabha.gov.in/) https://nptel.ac.in/content/storage2/courses/102103012/pdf/mod4.pdf

PS-FMB **-104- Medical Microbiology and Immunology**

Unit	Topic	Credits	Lectures	References
1	**Epidemiology of infectious diseases and Clinical bacteriology**	01	15	
	1.1 Epidemiology of infectious diseases 1.1.1 Epidemiological principals in prevention and control of Diseases 1.1.2 Measures of risks : frequency measures, morbidity,mortality ,natality(birth) measures, measures of association, measures of public health impact 1.1.3 Public health surveillance: i. Identifying health problems for surveillance ii. Collecting data for surveillance, iii. Analyzing and interpreting data, iv. Knowledge of the Geo-sentinel network and Geographical Information mapping of various diseases		04	Nikuchia,N W. Ahrens, I. Robert H Friis www.cdc.gov
	1.2 Clinical bacteriology 1.2.1 Time kill curves 1.2.2 Serum killing curves 1.2.3 Testing antibiotic combinations 1.2.4 Methicillin(Oxacillin) resistance in *Staphylococcus*spp 1.2.5 Beta lactam antibiotic resistance 1.2.6 Vancomycin resistant Enterococci 1.2.7 Handling and Discarding of biological specimens		04	Bailey and Scotts Sahem
2	**Emerging and Re-emerging Diseases.**	01	15	SuparnaDuggal
	2.1 Emerging infectious diseases in India(with emphasis on Etiology, Transmission, Pathogenesis, Clinical Manifestations, Lab diagnosis, Prophylaxis, Prevention, Treatment and Epidemiology. Viral Infections:Pandemic Influenza, Swine flu, Bird flu, SARS, Covid 19, Nipah Virus, Chikungunya, Ebola, Dengue .		10	Friis, Robert https://wwwnc.cdc.gov/eid/ https://www.coronavirus.gov/
	2.2 Bacteria: MDR-TB, XDR-TB, Legionellosis, Listeriosis, MRSA		04	
	2.3 Fungi: Nonalbicans candida, Histoplasmosis.		01	
3	**Tolerance and Regulation of Immune system and Hypersensitivity**	01	15	

	3.1 Immuno tolerance **3.1.1** Central Tolerance **3.1.2** Peripheral Tolerance **3.1.3** Tolerance Induction **3.1.4** T-cell Tolerance 3.1.5 B-cell Tolerance		07	Kuby 6th Ed Roitt's Pathak and Palan.
	3.2 Regulation of Immune response 3.2.1 Mechanisms of tolerance induction (related experimentation using transgenic animals) 3.2.2 Regulation of immune responses by: antigen, antigen-antibody complexes		04	Roitt's
	3.3 Overview and Classification of Hypersensitivity (type I,II,III,IV).		04	Kuby 6th Ed
4	**Immunobiology**	01	15	
	4.1 The Human Microbiome 4.1.1 Introduction to Gut microbiome- types of organisms 4.1.2 Functions and their role in health and disease 4.1.3 The Human Microbiome Project		06	Pathak and Palan. Fahim Halim Khan
	4.2 Molecular basis of diversity of immunoglobulin molecules. 4.2.1 Multigene organization of Ig genes. 4.2.2 Variable-Region Gene Rearrangements. 4.2.3 Mechanism of Variable-Region DNA Rearrangements. 4.2.4 Generation of antibody diversity. 4.2.5 Manipulations of the immune response.		06	Kuby 6th Ed
	4.3 Recent advances in Innate immunity including receptors involved and signalling system 4.3.1 Induced Cellular Innate Responses (TLRs, NLRs, CLRs), Antimicrobial Peptides, Interferon, Cytokines		03	Janeway's Immuno-biology

Self-Learning topics (Unit wise)

Sub- Unit	Topics

1.1.2	Measures of risks
2.1	Swine Flu and H5N1 virus
3.3	Hypersensitivity
4.2.2	Variable-Region Gene Rearrangements.

Online Resource
Online module: Measures of risks https://nptel.ac.in/courses/109/106/109106095/ (you tube link-https://youtu.be/ZhFUlsAoWd0) Dr Ramakrishnan IIT Madras. Online module: Swine Flu and H5N1 virus https://www.coursera.org/lecture/hkuepidemics/video-2-6-swine-influenza-and-the-2009-pandemic-h1n1-s7LON https://www.coursera.org/lecture/hkuepidemics/video-2-4-emergence-of-highly-pathogenic-h5n1-avian-influenza-virus-in-asia-Jn49f Online module: Hypersensitivity https://www.youtube.com/watch?v=QEzH9zepZZA Essentials in Immunolgy by Dr. R. Manjunath, Dr.Dipankar Nandi, Prof. Anjali Karande, Department of Biochemistry, IISc Bangalore Online Module: Variable-Region Gene Rearrangements. i. https://nptel.ac.in/courses/102/105/102105083/ and i. https://nptel.ac.in/courses/102/105/102105083/ OR https://nptel.ac.in/courses/104/108/104108055/

Part 4: Detailed scheme Practicals

Course Code: PS-FMB - **1P1**

1	Practicals based on PS-FMB -101
	1. Isolation and Purification of coliphages from sewage 2. Phage Typing of E. coli and Salmonella strains. 3. Study of One Step Growth Curve of Lambda phage / T4 Phage. 4. Study of Lysogeny in E. coli. 5. Isolation of Lysozyme from egg white. 6. Preparation of protoplast using Lysozyme. 7. Study of cell cytology using Phase contrast Microscopy. Demonstration 8. Study of Cell structure using Confocal Microscopy. Demonstration **9.** Study of Cell structure using Fluorescence Microscopy. Demonstration
2	Practicals based on PS-FMB -102
	1**.**Isolation, detection of plasmid and Transformation 2. Conjugation 3. Transduction 4. Curing of plasmids 5.Southern hybridization technique 6. Protein electrophoresis 7. Problems on population genetics and Recombination 8. LC-MS protein expression profile , MALDI-TOF, Microarray- Visit to research institute **9.** Micropipetting- basic techniques- negative and positive pipetting, viscous and non viscous fluids 10. Training in Basic Molecular Biology techniques (Continuous internal evaluation)

Course Code: PS-FMB - **1P2**

1	Practicals based on PS-FMB -103
	1. Preparation of buffers 2. Determination of pK and PI value for an amino acid 3. Determination of the isoelectric point of the given protein 4. Isolation of cholesterol and lecithin from egg yolk 5. Identification of fatty acids and other lipids by TLC 6. Isolation of lactose from bovine milk 7. Estimation of total sugars by phenol - sulphuric acid method 8. Extraction, isolation, purification and estimation of albumin and globulin from egg white. 9. Interpretation of Ramachandran plot 10. Preparation of liposomes 11. Estimation of Fe, Cu, and Phosphorous (Demonstration) 12. DNA: RNA Hybridization Kinetics, Tm value, cot value- calculations
2	Practicals based on PS-FMB -104
	1. Detection of specific types of Antibiotic Resistance: MRSA,VRE,ESBL 2. Antibiotic susceptibility testing by Conventional broth microdilution method

	according to CLSI guideline. 3. Checker Board Assay for detecting synergistic activity of two antibiotics. 4. Mono - Spot Test for diagnosis of Chickengunya (Demonstration expt.) 5. Acid fast staining for *Mycobacterium spp.* 6. Preparation and Quality Analysis of media. 7. Rapid identification for Dengue virus (IgM &IgG) by kit method . 8. Assay of the Antibiotic Activity of Serum 9. Time Kill Kinetics Assay for evaluation of antimicrobial agents , using CLSI guideline 10. Problems on Epidemiology: based on diseases caused by SARS, Corona, Swine flu, Bird Flu, Nipah Virus, Chikungunya, Dengue, Legionellosis, Listeriosis, prions, Nonalbicans candida, Histoplasmosis. 11. For internal assessment: Case study for epidemiology of the diseases/. Collection of data, criteria, methodology etc. Assignment to be submitted.

Part 5- The Scheme of Teaching and Examination is as under:

Semester – II
Summary

Sr. No.	Choice Based Credit System			Subject Code	Remarks
1	Core Course (**Microbiology**)			PS-FMB 201, PS-FMB 202, PS-FMB 203, PS-FMB 204, PS-FMB 2P1, PS-FMB 2P2	
2	Elective Course	Discipline Specific Elective (DSE) Course			
		2.1	Interdisciplinary Specific Elective (IDSE) Course		
		2.2	Dissertation/Project		
		2.3	Generic Elective (GE) Course		
3	Ability Enhancement Courses (AEC)				
4	Skill Enhancement Courses (SEC)				

First Year Semester II Internal and External Detailed Evaluation Scheme

Sr. No.	Subject Code	Subject Title	Periods Per Week						Internals				Total Marks
			Units	S.L.	L	T	P	Credit	S.L.E.	CT+AT= 15+5	PA	SEE	
1	PS-FMB-201	Virology &Cell Biology- II	4	20%*	4	0	0	2	10	20	10	60	100
2	PS-FMB-202	Genetics and Molecular Biology-II	4	20%*	4	0	0	2	10	20	10	60	100
3	PS-FMB-203	Biochemistry-II	4	20%*	4	0	0	2	10	20	10	60	100
4	PS-FMB-204	Medical Microbiology-II	4	20%*	4	0	0	2	10	20	10	60	100
5	PS-FMB-2P1	Practicals Based PS-FMB -101 + Practicals Based PS-FMB -102			0		6	2				100 (80+20)	100
6	PS-FMB- 2P2	Practicals Based PS-FMB -103 + Practicals Based PS-FMB -104			0		6	2				100 (80+20)	100
	Total Hours / Credit							20	Total Marks				600

***One to two lectures to be taken for CONTINUOUS self -learning Evaluation.**

First Year Semester II - Units – Topics – Teaching Hours

S. N	Subject Code	Subject Unit Title		Hours/Lectures	Total No. of hours/lectures	Credit	Total Marks
1	PS-FMB - 201	1	Viral Disease in Plants:	15	60 L	2	100 (60+40)
		2	Viral Diseases in Animals:	15			
		3	Cell Biology (Cell division, Cell Cycle and Cancer Biology)	15			
		4	Cell Biology ((Cell Communication)	15			
2	PS-FMB - 202	1	Genetic exchange and recombination	15	60 L	2	100 (60+40)
		2	Drosophila development and population genetics	15			
		3	Metagenomics, proteomics and epigenetics	15			
		4	Cytoplasmic Inheritance & Chromosomal Rearrangements	15			
3	PS-FMB - 203	1	Enzymology	15	60 L	2	100 (60+40)
		2	Signalling and stress	15			
		3	Degradation of C1 and aromatic compounds	15			
		4	Regulation of gene expression	15			
4	PS-FMB - 204	1	Immunological disorders	15	60 L	2	100 (60+40)
		2	Clinical research and Quality Assurance and Validation in Pharmaceutical Industry	15			
		3	Transplantation & Cancer Immunology	15			
		4	Recent Advances in Diagnostic and Experimental Techniques in Immunology.	15			
5	PS-FMB - 2P1	1	Practicals based on PS-FMB -201	3	60 x2= 120 lectures per batch	2	100 (80+10 +10)
		2	Practicals based on PS-FMB -202	3			

9	PS-FMB - 2P2	1	Practicals based on PS-FMB -203	3	60x2= 120 lectures per batch	2	100 (80+10 +10)
		2	Practicals based on PS-FMB -204	3			
			TOTAL			20	600

- **Lecture Duration – 45 Minutes = 0 .75 Hours. (45 Lectures equivalent to 33.75 hours)**
- **One Credit =16.87 hours equivalent to 17 Hours**

L: Lecture: Tutorials P: Practical Ct-Core Theory, Cp-Core Practical, SLE- Self learning evaluation CT-Commutative Test, SEE- Semester End Examination , PA-Project Assessment, AT- Attendance

Part 6: Detail Scheme Theory

First Year Semester – II Units – Topics – Teaching Hours

Curriculum Topics along with Self-Learning topics - to be covered, through self-learning mode along with the respective Unit. Evaluation of self-learning topics to be undertaken before the concluding lecture instructions of the respective Unit

PS-FMB **-201 (Virology & Cell Biology- II)**

Unit	Topic	Credits	Lectures	References
1	Baltimore classification of viruses		15	
	General characters and genomic structure, and replication for:			
	1.1 Class I: Double stranded DNA (dsDNA) viruses- Herpesviridae. Class II: Single stranded DNA (ssDNA) viruses-Parvoviridae.		04	I. Longman
	1.2 Class III: Double stranded RNA (dsRNA) viruses-*Rheoviridae* Class IV: Single stranded RNA (ssRNA) viruses positive-sense RNA genome- *Coronaviridae* Class V: Single stranded RNA (ssRNA) negative-sense RNA genome viruses-*Paramyxoviridae*.		06	Wagner E Teri shors
	1.3 Class VI: Positive-sense ssRNA reverse transcriptase viruses-HIV. Class VII: Double stranded DNA (dsDNA) reverse transcriptase viruses- Hepatitis B.		05	
2	**Viruses: Detection, Enumeration and Antivirals**	01	15	
	2.1 Sampling techniques 2.1.1. Processing of samples – Enrichment and concentration 2.2.2. Direct methods of detection – light microscopy (inclusion bodies), electronmicroscopy and fluorescence microscopy 2.2.3. Immunodiagnosis, hemagglutination and hemagglutination-Inhibition tests,Complement fixation, Neutralization, Western blot, Radioactive Immunoprecipitation Assay (RIPA), Flow cytometry and Immunohistochemistry. 2.2.4. Nucleic acidbased diagnosis: Nucleic acid hybridization, polymerase chainreaction, microarray and nucleotide sequencing, LINE		12	Flint S Wagner E Matthews

	probe assay 2.2.5. Infectivity assay for animal and bacterial viruses - plaque method, pockcounting, end point methods, LD50, ID50, EID50, TCID50 2.2.6. Infectivity assays of plant viruses			
	2.2 Antivirals: Interferons, designing and screening for antivirals, mechanisms of action, antiretrovirals — mechanism of action and drug resistance		03	Flint S. J
3	**Cell Biology (Cell division, Cell Cycle and Cancer Biology**	01	15	
	3.1 Mechanism of cell division: Phases of cell cycle, Mitosis, Meiosis		03	Alberts B,
	3.2 Cell cycle and Programmed cell death: Control system, intracellular control of cell cycle events, Apoptosis, extracellular control of cell growth		05	Karp
	3.3 Genetic rearrangement in progenitor cells, oncogenes, tumor suppressor genes, cancer and cell cycle, virus induced cancer, Virus induced cell transformation and oncogenesis, Mechanism of cell transformation by RNA viruses and by DNA tumor viruses, Retrovirusmediated oncogenesis, metastasis, interaction of cancer cells with normal cells		07	Pranavkumar
4	**Cell Biology (Cell Communication)**	01	15	
	4.1 Cell communication: Extracellular signal molecules, nitric oxide,carbon monoxide and hydrogen sulphide gas signal,classes of cell-surface receptor proteins		06	Alberts B Karp
	4.2 Signaling through enzyme linked cell surface receptors: Docking sites, Ras, MAP kinase, Pl-3 kinase, TGF		04	
	4.3 Signaling in plants: Serine / Threonine kinases, role of ethylene, Phytochromes		02	Weaver R
	4.4 Cell signaling and communication in *Dictyostlium*, Myxobacteria, quorum sensing. Biofilms		03	Hamilton W.

Self-Learning topics (Unit wise)

Unit	Topics
1.2	DNA virus
2.2.3	Immunodiagnosis
3.3	Oncogenes, tumor suppressor genes, cancer and cell cycle
4.2	Cell signalling

Online resource
Online module: DNA virus https://www.youtube.com/watch?v=73nXMQO-new&feature=youtu.be https://www.classcentral.com/course/virology-952 Online module: Immunodiagnosis https://onlinecourses.swayam2.ac.in/cec20_bt15/preview Online module: Oncogenes, tumor suppressor genes, cancer and cell cycle https://onlinecourses.swayam2.ac.in/cec20_ma14/preview Online module: Cell signalling https://ocw.mit.edu/courses/biology/7-016-introductory-biology-fall-2018/lecture-videos/lecture-20-cell-signaling-12014overview/

PS-FMB -202 (Genetics and Molecular Biology-II)

Unit	Topic	Credits	Lectures	References
1	**Rational mutagenesis and molecular tools for genetics**	01	15	
	1.1 Rational Mutagenesis 1.1.1 Oligonucleotide directed mutagenesis – with M13 and plasmid DNA 1.1.2 PCR amplified oligonucleotide directed mutagenesis 1.1.3 Random mutagenesis – with degenerate oligonucleotide primer and with nucleotide analogues, Error-prone PCR, DNA shuffling Mutant proteins with unusual amino acids		04	Glick
	1.2 Molecular tools 1.2.1 Labeled tracers (autoradiography, phosphorimaging, liquid scintillation counting, non-radioactive tracers), Overview of Nucleic acid hybridization, In situ hybridization, DNA sequencing, Restriction mapping 1.2.2 Mapping and quantifying transcripts (S1 mapping, primer extension, run-off transcription) Measuring transcription rates in vivo (Nuclear run – on transcription, reporter gene transcription), 1.2.3 Assaying DNA –protein interactions (filter binding, gel mobility shift, DNase and DMS footprinting, knockouts)		08	
	1.3 Polymerase Chain Reaction 1.3.1 Fundamentals of the PCR, 1.3.2 Variations/ Modifications of PCR: Reverse transcriptase PCR, Differential display PCR, Real time Fluorescent PCR(taq man and SYBR green), Hot- Start PCR, Multiplex PCR, Nested PCR, 1.3.3 Applications		03	
2	**Cytogenetics**	01	15	
	2.1 Structure of Chromosome - Heterochromatin, Euchromatin, Polytene Chromosomes.		02	iGenetics – Russel3rd edition

	2.2 Variation in Chromosomal Structure and Number: Deletion, Duplication, Inversion, Translocation, Aneuploidy, Euploidy and Polyploidy and Syndromes- Klinefelter, Turner, Cri-du-Chat, Trisomy -21, Trisomy 18 and Trisomy 13. karyotype, Banding techniques,use of Human Cyto-genetics in Medical science.		07	Genetics- 5th edition
	2.3 Sex Determination and Sex Linkage: Mechanisms of Sex Determination (XX-XY, ZZ-ZW, XX-XO) Dosage Compensation and Barr Body. Genetic Linkage, Crossing Over and Chromosomal Mapping: Tetrad Analysis; Two-point Cross; Three-point Cross; Pedigree Analysis.		06	iGenetics 3rd edition
3	**Transposons and cancer genetics**	01	15	
	3.1 Transposable Elements in Eukaryotes Ac and Ds Elements in Maize, P Elements and Hybrid Dysgenesis in Drosophila, Retrotransposons		04	Genes IX - Lewin
	3.3 The Genetic and Evolutionary Significance of Transposable Elements Transposons and Genome Organization, Transposons and Mutation, Rearrangement of Immunoglobulin Genes, Evolutionary Issues Concerning Transposable Elements		04	
	3.4 Genetic basis of cancer Cancer: Inherited Cancers and Knudson's Two-Hit Hypothesis, Cellular Roles of Tumor Suppressor Proteins, Genetic Pathways to Cancer		07	
4	**Social, legal and Ethical issues of genetic technology**	01	15	Institute of Medicine 1994. Assessing Genetic Risks: Implications for Health and Social Policy.
	4.1 Social issues - public opinions against the molecular technologies		04	
	4.2 Legal issues – legal actions taken by countries for use of the molecular technologies.		04	
	4.3 Ethical issues – ethical issues against the molecular technologies. Bioethics – Necessity of Bioethics, different paradigms of Bioethics – National & International.		05	

	4.4 Intellectual Property Rights – Why IPR is necessary, TRIPS & IPR, IPR – national & international scenario, IPR protection of life forms.		02	

Self-Learning topics (Unit wise)

Sub- Unit	**Topics**
1.2.1	Autoradiography, liquid scintillation counting
2.1, 2.2	Structure of Chromosome and Variation in Chromosomal Structure and Number
3.4	Genetic basis of cancer
4.3	Ethical issues against the molecular technologies.
4.4	Intellectual Property Rights

Online Resource
Online module: Autoradiography, liquid scintillation counting https://nptel.ac.in/courses/102/107/102107028/ (lectures 8-12) Online module: Structure of Chromosome and Variation in Chromosomal Structure and Number https://nptel.ac.in/courses/102/104/102104052/ (module 1) Online module: Genetic basis of cancer https://dth.ac.in/medical/courses/pathology/8/5/index.php Online module: Ethical issues against the molecular technologies. https://www.youtube.com/watch?v=3XgP5E998iU Online module: Intellectual Property Rights https://nptel.ac.in/courses/109/106/109106137/

PS-FMB **-203 (Biochemistry- III)**

Unit	Topic	Credits	Lectures	References
1	**Enzymology**		15	
	1.1 Mechanisms of enzyme catalysis: Substrates induce conformational changes in enzymes, Detailed mechanisms of enzyme catalysis- serine proteases, triose phosphate isomerase, lysozyme, lactate and alcohol dehydrogenases, catalytic antibodies, isozymes, ribozymes.		05	Voet, Lehninger Harper
	1.2 Enzyme kinetics- Kinetics of enzyme catalyzed reactions, Multiple factors affecting the rates of enzyme catalyzed reactions, enzyme inhibition		04	Harper, Conn & Stumpf
	1.3 Regulation of enzyme activities- Regulation of enzyme quantity, Allosteric regulation and covalent modification, Reversible covalent modification in regulation of mammalian proteins		04	Harper Conn & Stumpf
	1.4 Enzymes used in clinical biochemistry as reagents, diagnostics and therapy. Role of immobilized enzymes in industry.		02	Harper
2	**Signalling and stress**		15	
	2.1. Introduction to two-component signalling systems: Response by facultative anaerobes to anaerobiosis, nitrate and nitrite, nitrogen supply, inorganic phosphate supply		03	David White Lehninger
	2.2 Effect of oxygen and light on the expression of photosynthetic genes in purple photosynthetic bacteria, response to osmotic pressure and temperature, response to potassium ion and external osmolarity, response to carbon sources		04	
	2.3 Bacterial response to environmental stress- heat-shock response, repairing damaged DNA, the SOS response, oxidative stress,		04	
	2.4 Synthesis of virulence factors in response to temperature, pH, nutrient, osmolarity and quorum sensors, chemotaxis, photoresponses, aerotaxis		04	

3	**Degradation of C1 and aromatic compounds**			
	3.1 Biodegradation of Microbial growth on C1 Compounds Study of Methylotrophs, Methanogens, Carboxidotrophs, Cynogens and cynotrophs (Cyanide, Methane, Methanol, methylated amines, carbon monoxide)		05	Atlas and Bartha, Gottschalk, David White
	3.2 Microbial degradation of aromatic hydrocarbons and aromatic compounds (via catechol, protocatechuate, meta-cleavage of catechol and protocatechuate, dissimilation of catechol and protocatechuate, homogentisate and other related pathways).		06	
	3.3 Metabolism of xenobiotics		04	Harper Atlas and Bartha
4	**Regulation of Gene expression**		15	Nelson D. L. and Cox M. M. (2002) Lehninger's Principles of Biochemistry Brock Stryer Watson
	4.1 Principles of Gene Regulation		01	
	4.2 Regulation of Gene Expression in Prokaryotes Overview : Negative and positive regulation in operons. Induction of SOS response, synthesis of ribosomal proteins, regulation by genetic recombination, Regulation of sporulation.		05	

	4.3 Regulation of Gene Expression in Eukaryotes Overview : Regulatory sequences - enhancers, silencers response elements, Heterochromatin, euchromatin. Chromatin remodelling, DNA-protein interactions, Novel - Regulation of galactose metabolism in yeast, regulation by phosphorylation of nuclear transcription factors, regulatory RNAs, riboswitches, RNA interference, synthesis and function of miRNA molecules, significance of CRIS incontrolling spermiogenesis.		07	Krahling et al.
	4.4 Gene regulation at steps after transcription initiation		02	Watson

Self-Learning topics (Unit wise)

Sub- Unit	**Topics**
1.2	Enzyme kinetics
2.4	Quorum sensors
4.2	Overview : Negative and positive regulation in operons.
4.3	RNA interference, miRNA

Online Resource
Online Module: Enzyme kinetics https://www.youtube.com/watch?v=pHtxWquZV8k https://www.youtube.com/watch?v=aIR-SnRPwSA (https://www.swayamprabha.gov.in/) Online Module: Quorum sensors http://eacharya.inflibnet.ac.in/data-server/eacharya-documents/55d44ff9e41301fd23d8facc_INFIEP_203/1319/ET/203-1319-ET-V1-S1__lecture_2.pdf Online Module: Overview : Negative and positive regulation in operons. https://www.youtube.com/watch?v=RSzYOKcdGRA (https://www.swayamprabha.gov.in/) Online Module: RNA interference, miRNA https://www.youtube.com/watch?v=5aYyjWw-Pxo (NPTEL) https://nptel.ac.in/content/storage2/courses/104108056/module10/PNR%20lecture%2038.pdf

PS-FMB **-204 (Medical Microbiology and Immunology- II)**

Unit	Topic	Credits	Lectures	References
1	**Immunological disorders**	01	15	
	1.1 Immunodeficiency disorders – Pathophysiology, diagnosis, prognosis and therapeutic approaches: 1.1.1 Humoral deficiencies, 1.1.2 Tcell deficiencies, 1.1.3 combined deficiencies, 1.1.4 complement deficiencies 1.1.5 Treatment Approaches for Immunodeficiency 1.1.6 Secondary Immunodeficiency & AIDS		08	Tizard Fahim Halim Khan Pathak&Palan Kuby 6th Ed
	1.2 Autoimmune diseases 1.1.1 Theories of autoimmunity 1.1.2 Mechanisms 1.1.3 Pathogenic effects of autoantibody 1.1.4 Pathogenic effects of complexes with auto antigens 1.1.5 T cell mediated hypersensitivity as a Pathogenic factor in autoimmune diseases. 1.1.6 Autoimmune disorders Rheumatoid arthritis, Systemic Lupus Erythomatosus (SLE), Guillain-Barré Syndrome , Myasthenia gravis,Ankylosing spondylitis 1.1.7 Diagnosis and Treatment of Autoimmune Diseases		07	Tizard Pathak&Palan Roitt's Kuby 6th Ed
2	**Clinical research andQuality Assurance and Validation in Pharmaceutical Industry**	01	15	
	2.1. Introduction to Clinical Research. 2.1.1 Good Clinical practice Guidelines 2.1.2 Ethical aspects of Clinical Research . Regulatory Requirements in clinical research 2.1.3 Clinical Research Methodologies and Management 2.1.4 Clinical Data Management and Statistics in Clinical Research 2.1.5 Data analysis and Medical Writing in Clinical Research		07	David Machim Eleanor McFadden

	2.2 Quality Assurance and Validation in Pharmaceutical Industry 2.2.1 Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in pharmaceutical industry. 2.2.2 Quality assurance and quality management in pharmaceuticals ISO, WHO and US certification. 2.2.3 Safety profile of drugs: i. Pyrogenicity testing ii. Mutagenicity and Carcinogenicity testing iii. Teratogenicity testing iv. Adverse Drug Reactions v. In vivo and in vitro drug interactions 2.2.4 . Regulatory authorities and its role: FDA and Pharmacopeia (IP, UK, US)		08	Kokate C. K Mannfred A. Micheles P. S OsolArther
3	**Transplantation & Cancer Immunology**	01	15	
	3.1 Transplantation Immunology 3.1.1 Antigens Involved in Graft Rejection 3.1.2 Allorecognition 3.1.3 Graft Rejection-Role of APCs & Effector Cells 3.1.4 Graft v/s Host Diseases 3.1.5 Immuno Suppressive Therapies 3.1.6 The foetus as an allograft		08	Phatak&Palan Kuby-7th Ed
	3.2 Cancer immunology 3.2.1 Tumors of the Immune System 3.2.2 Tumor Antigens 3.2.3 Tumor Evasion of the Immune System 3.2.4 Cancer Immunotherapy 3.2.5 Monoclonal Antibodies and engineered Antibody for Immunotherapy		07	Kuby-7th Ed Saeed et al, 2017
4	**Recent Advances in Diagnostic and Experimental Techniques in Immunology**	01	15	
	4.1 Invitro and Invivo system 4.1.1 In vitro systems –Quantification of cytokines (ELISPOT assay), functional assays for phagocytes and cytokines (cytotoxicity and growth assays) 4.1.2 In vivo systems – Experimental animals in immunology research (Inbred animal strains, Knockout mice, transgenic animals), Animal models for autoimmunity		05	Freshney R. Ian Kuby-6th Ed

	4.2 Experimental techniques in Immunology 4.2.1 Assays of Cell Death 4.2.2 Immunofluorescence-Based Imaging Techniques 4.2.3 Fluorescence-activated cell sorter		05	Kuby-7th Ed
	4.3 Modern Diagnostic Methods: 4.3.1 Microarrays. 4.3.2 lab-on-a-chip (LOC) 4.3.3 Next generation Sequencing 4.3.4 Recent Advances in ELISA		05	Kuby-7th Ed Current Published papers on recent advances to be referred.

Self-Learning topics (Unit wise)

Unit	**Topics**
1.2.1	Mechanisms of Autoimmunity
2.1.1	Good Clinical Practice
3.3	Graft Rejection/ Acceptance
4.3	lab-on-a-chip (LOC)

Online Resource
Online module: Mechanisms of Autoimmunity https://nptel.ac.in/courses/104/108/104108055/ IISc Bangalore Online module: Good Clinical Practice https://nptel.ac.in/courses/127/106/127106009/ IIT Madras Online module: Graft Rejection/ Acceptance https://nptel.ac.in/courses/104/108/104108055/ IISc Bangalore Online module: lab-on-a-chip (LOC) https://nptel.ac.in/courses/102/105/102105068/ https://nptel.ac.in/courses/102/105/102105068/ NPTEL course,IITKharagpur

Part 7: Detailed scheme Practicals

Course Code: PS-FMB - **2P1**

1	Practicals based on PS-FMB -201
	1. Egg inoculation and cultivating animal virus in embryonated egg. Demonstration 2. Cultivation of macrophage cell lines and study of cell viability 3. Study of Mitosis. 4. Study of Meiosis 5. Estimation of NO (Nitric Oxide) produced by Macrophages. 6. Study of Cell membrane integrity using uptake of neutral red. 7. Write a review w.r.t. Techniques used to study cell cycle. 8. Assignment on Animal viruses – Epidemiology, Transmission 9.
2	Practicals based on PS-FMB -202
	1. Study of Chromosomal Aberrations- Deletion, Duplication, Inversion, Translocation and Syndromes- Trisomy 21 Trisomy 13 Trisomy 18 2. Mapping based on Tetrad Analysis and Three Point Cross. 3. Pedigree Analysis- Autosomal and Sex-Linked 4. Primer design and PCR 5.Karyotyping 6.Scintillation technique 7.Case study/ Report writing on Ethical/Legal Issues/IPR 8. Random mutagenesis using analogues

Course Code: PS-FMB - **2P2**

1	Practicals based on PS-FMB -203
	1. Purification of an extracellular enzyme(βamylase) by salting out and dialysis 2. Study of enzyme kinetics – (Effect of enzyme and substrate concentration, Effect of pH, temperature and inhibitors on enzyme activity). 3. Demonstration of proteolytic activity 4. Determination of glucose isomerase present intracellularly in *Bacillus spp.* 5. Adaptation of *E. coli* to anaerobiosis 6. Chemotaxis of *Pseudomonas* 7. Effect of temperature and water activity on swarming of *Proteus* 8. Different bacteriolytic response associated with addition of lysozyme and salt. 9. Microbial degradation of polycyclic aromatic hydrocarbon enrichment, isolation and screening of bacteria 10. PAH degradation studies
2	Practicals based on PS-FMB -204

	1. SRID: For detection of immune deficiency and Complement deficiency. 2. Rheumatoid factor test for laboratory diagnosis of Rheumatoid arthritis 3. Lupus erythematosus (LE) cell preparation-Principle, Procedure and Significance to be explained during the practicals using permanent slides/ color atlas of diagnostic immunology/Microbiology 4. RIST and RAST- Principle, Procedure and Significance to be explained during the practicals using power point presentation/ youtube. 5. Immunodiagnosis by ELISA 6. Sterility testing of Pharmaceutical products, according to the Pharmacopoeia 7. Ames test to asses mutagenic potential of chemical compounds 8. Internal Assignment on drug discovery, different stages of clinical trials, FDA approval and marketing of a drugs.

REFERENCES:

Semester I

PS-FMB -101

1) Understanding Viruses – Teri Shors. Jones and Bartlett pub.
2) Bacterial and Bacteriophage Genetics – Edward Birge
3) Basic Virology, Wagner E,K; Hewlett, M.J, Bloom, D.C., Camerini, D, 3rded, 2008, Blackwell Publishing
4) Principles of Virology – Flint, Enquist, Racaniello&Skalka, Vol I and II. ASM
5) Azimi T, Mosadegh M, Nasiri MJ, Sabour S, Karimaei S, Nasser A. Phage therapy as a renewed therapeutic approach to mycobacterial infections: a comprehensive review. *Infect Drug Resist*. 2019;12:2943-2959https://doi.org/10.2147/IDR.S218638
6) Chemistry of Viruses – Knight C. Springer Verlag. NY
7) Virology – Delbecco and Giasberg. Harper and Ravi Pub. NY.
8) Molecular Biology of The Cell – Albert, Johnson, Lewis, Raff, Roberts &Walter.
9) Molecular Cell Biology. Lodish ,Birk, and Zipursky. Freeman
10) The Structure and Dynamics of Cell Membrane. – Lipowsky and Sackmann.Elsevier.,
11) Cell Biology. Karp G.7thEdn. International Student Version, Wiley. 2013.
12) International Congress on Taxonomy of Viruses:http://www.ncbi.nlm.nih.gov/ICTV
13) The Cell: A Molecular Approach, Cooper,G;Hausman, R., 5th edition, 2009, ASM Press

PS-FMB -102

1) iGenetics- A Molecular Approach, Russell, P.J., 3rd edition, 2010, Pearson International edition
2) Fundamental Bacterial Genetics, Trun, Trempy, 1st edition, 2004, Blackwell Publishing
3) Molecular Biology of the Gene, Watson, Baker, Bell, Gann, Levine, Losick, 7th edition, 2007, Pearson Education
4) Genes IX, Lewin, B., 2006, Jones and Bartlett Publishers
5) Genetics: A Conceptual Approach, Benjamin Pierce 4th edition, 2008, W. H. Freeman & Co
6) Principals of Genetics, Snustad& Simmons, 6th edition, 2012, John Wiley & Sons Inc
7) Molecular biology –Genes to proteins 3rd ed. by Burton E. Tropp (Jones & Bartlett publishers)
8) Molecular Genetics of bacteria, 3rd Edition by Larry Snyder and Wendy Champness (ASM press)
9) Molecular biology -Understanding the Genetic Revolution by David P. Clark(Elsevier Academic press)
10) Molecular Biotechnology Principles and applications of Recombinant DNA 4th edi Glick, Pastermak, Patten
11) Recombinant DNA J.D. Watson 2nd ed
12) Molecular Biology by R. F. Weaver 3rd edition, McGraw-Hill international edition

EPIGENETICS --ncRNA edited by C. David Allis The Rockefeller University, New York
Thomas Jenuwein Research Institute of Molecular Pathology (IMP), Vienna

PS-FMB -103

1) Analytical Chemistry, B.K. Sharma, Krishna Prakashan Media ltd, 2006.
2) Bacterial metabolism, Gottschalk, Springer-Verlag, 1985
3) Biochemical calculations, Segel I.R., John Wiley and Sons, 1995
4) Biochemistry - The Chemical Reactions of Living Cells, 2nd Edition, David Metzler. Academic Press, 2003.
5) Biochemistry 3rd edition, Mathew, Van Holde and Ahern, Pearson Education
6) Biochemistry, 4th edition, Voet D. and Voet J.G., John Willey and Sons Inc., 1995
7) Biochemistry.Berg, J. M., Tymoczko, J. L., Stryer, L., &Stryer, L. New York: W.H. Freeman, 2002
8) Conn, Stumpf, P. K., Bruening, G. R. H (1987) Outlines of Biochemistry, 5th edition, John Wiley & sons
9) Endocrinology (2007) 6th ed., Hadley, M.C. and Levine, J.E. Pearson Education (New Delhi), Inc. ISBN: 978-81-317-2610-5.
10) Harper's illustrated biochemistry. Rodwell, V. 30th ed. New York: Lange Medical Books/McGraw-Hill, 2015.
11) Principles of Biochemistry, Horton, R. and Moran, L., 5th edition, 2011, Prentice Hall
12) Principles of Biochemistry, 4th edition, Zubay, G., Wm.C. Brown Publishers, 1998
13) Principles of Biochemistry, Lehninger A.L., Cox and Nelson, 4th edition.
14) Textbook of Biochemistry with Clinical Correlations (2011) Devlin, T.M. John Wiley & Sons, Inc. (New York), ISBN: 978-0-4710-28173-4.
15) The physiology and biochemistry of prokaryotes, White D., Oxford University Press, 2000

PS-FMB -104

1) Introduction to Diagnostic Microbiology for the Laboratory Sciences, Maria Dannessa Delost,2015, Jones and Bartlett Learning
2) Ananthanarayan and Paniker's Textbook of Microbiology, by Reba Kanungo, 10thedUniversities Press; Tenth edition, 2017
3) Bailey and Scotts Diagnostic Microbiology Forbes, Sahem et al 12thed, Moshby
4) A brief guide to emerging infectious diseases and zoonoses.WHO. 2016.
5) Understanding emerging and re-emerging infectious diseases by SuparnaDuggal and Jyoti Mantri Himalaya Publishing House
6) Friis, Robert H_Sellers, Thomas A, Epidemiology for Public Health Practice-Jones and Bartlett Learning (2014).pdf.
7) https://wwwnc.cdc.gov/eid/Center for Disease control and Prevention
8) https://www.coronavirus.gov/
9) Kuby Immunology, Kindt, J. T., Osborne, A. B. and Goldsby, A. R., 6th edition, 2006, W. H. Freeman and company.
10) Kuby Immunology, Owen, J., Punt, J. and Stanford, S., 7th edition, 2013, International edition, Macmillan higher education.
11) Roitt's Essential Immunology, Delves, J. P., Martin, J. S., Burton, R. D. and Roitt, M. I., 12th edition, 2011, John Wiley & Sons.
12) Immunology – Essential and Fundamental, SulabhaPathak and UrmiPalan. 3rd edition Capital publishing company.
13) The Elements of immunology- Fahim Halim Khan- Pearson Education.

14) Immunology an introduction, Tizard, R. I., 4th edition, 1995, Saunders College Pub.
15) Janeway's Immunobiology –the immune system in health and disease, Murphy, M. K., Travers, P., Walport, M. and Janeway, C., 6th edition, 2011, Garland Science
16) Handbook of Microbiological Quality Control, Pharmaceutical and Medical Devices Rosamund M Baird. (CRC Press)
17) Clinical Immunology – Principle & Practice 3rd ed. 2008 (Part -11 –Clinical diagnostic immunology)

Semester II

PS-FMB -201

1) Introduction to Plant Virology – BOS, I. Longman, London, NY.
2) Animal Virology – Fenner and White. Academic Press. NY
3) Virology – Dulbecco and Giasberg. Harper and Ravi Pub. NY.
4) Hamilton W. Allan, (1987) Biofilms: Microbial Interactions and Metabolic activities, in Ecology of Microbial Communities, (Eds. M. Fletcher, T. R. G. Gray and J. G. Jones) Cambridge University Press, Cambridge.
5) Edward K. Wagner, Martinez J. Hewlett, (2004), Basic Virology, Blackwell Publishing
6) Flint S. J., V. R. Racaniello, L. W. Enquist, V. R. Rancaniello, A. M. Skalka, (2003), Principles of Virology: Molecular Biology, Pathogenesis, and Control of Animal Viruses, American Society Microbiology, Chapters 3-13
7) Understanding Viruses – Teri Shors. Jones and Bartlett pub.
8) Haaheim L. R., J. R. Pattison and R. J. Whitley, (2002), A Practical Guide to Clinical Virology. 2nd Ed. Edited by, John Wiley & Sons, Ltd.
9) International Congress on Taxonomy of Viruses:http://www.ncbi.nlm.nih.gov/ICTV
10) Knipe David M., Peter M. Howley, Diane E. Griffin, Robert A. Lamb, Malcolm A. Martin, Bernard Roizman, Stephen E. Straus, (2007), Field's Virology, 5th Ed. Lippincott Williams & Wilkins
11) Luria S. E. et.al. (1978) General virology, 3rd Ed, New York. John Wiley and Sons.
12) Watson James D., Tania Baker, Stephen P. Bell, Alexander Gann, Michael Levine,Richard Lodwick (2004) Molecular Biology of the Gene, 5th Edition, Pearson Education, Inc. and Dorling Kindersley Publishing, Inc.
13) Weaver R., (2007) Molecular Biology, 4th Edition, McGrew Hill Science.
14) Molecular Biology of the Cell. Alberts B, Johnson A, Lewis J, Raff M, Roberts K, Walter P. 5thEdn. Taylor and Francis Group. 2008.
15) Cell Biology. Karp G.7thEdn. International Student Version, Wiley. 2013.
16) Molecular Cell Biology. Lodish H, Berk A, Kaiser CA, Krieger M, Bretscher A, Ploegh H, Amon A, Scott MP.7thEdn. W. H. Freeman. 2012.
17) Life Sciences- Fundamentals and Practices- I; Pranavkumar and Usha Mina; Pathfinder academy;2017

PS-FMB -202

1) Watson, Baker, Bell, Gann, Levine, Losick, “Molecular Biology of the Gene”, Fifth
2) Edition, Pearson Education (LPE)
3) Trun, Trempy, “Fundamental Bacterial Genetics”, Blackwell Publishing
4) Russell, P.J., “iGenetics- A Molecular Approach”, Third Edition, Pearson International Edition
5) Snustad& Simmons, “Principals of Genetics”, Third Edition, John Wiley & Sons Inc
6) Watson, Gilman, Witkowski, Zoller, “Recombinant DNA”, Second Edition, Scientific American Books
7) Klug & Cummings, “Concepts of Genetics”, Seventh Edition, Pearson Education (LPE)

8) Pierce, B.A., “Genetics- A Conceptual Approach”, Second Edition, W. H. Freeman & Co
9) Lewin, B., “Genes-IX”, Jones and Bartlett Publishers

PS-FMB -203

1) Bacterial metabolism, Gottschalk, Springer-Verlag, 1985
2) Biochemical calculations, Segel I.R., John Wiley and Sons, 1995
3) Biochemistry - The Chemical Reactions of Living Cells, 2nd Edition, David Metzler. Academic Press, 2003.
4) Biochemistry 3rd edition, Mathew, Van Holde and Ahern, Pearson Education
5) Biochemistry, 4th edition, Voet D. and Voet J.G., John Willey and Sons Inc., 1995
6) Biochemistry.Berg, J. M., Tymoczko, J. L., Stryer, L., &Stryer, L. New York: W.H. Freeman, 2002
7) Brock biology of microorganisms, 12thedMichael T Madigan; Thomas D Brock, San Francisco, CA : Pearson/Benjamin Cummings,2009
8) Conn, Stumpf, P. K., Bruening, G. R. H.(1987) Outlines of Biochemistry, 5th edition, John Wiley & sons
9) Harper's illustrated biochemistry. Rodwell, V. 30th ed. New York: Lange Medical Books/McGraw-Hill, 2015.
10) Krahling AM, Alvarez L, Debowski K, et al. CRIS-a novel cAMP-binding protein controlling spermiogenesis and the development of flagellar bending. PLoS Genet. 2013;9(12):e1003960. doi:10.1371/journal.pgen.1003960
11) Microbial ecology: Fundamentals and applications 4th ed. Ronald H.Atlas and Richard Bartha, Reprint 2005, Pearson education.
12) Molecular Biology of the Gene, 6th ed., Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M. and Losick, R., Cold Spring Harbor Laboratory Press, Cold spring Harbor (New York), 2008
13) Principles of Biochemistry, 4th edition, Zubay, G., Wm.C. Brown Publishers, 1998
14) Principles of Biochemistry, Lehninger A.L., Cox and Nelson, 4th edition.
15) The physiology and biochemistry of prokaryotes, White D., Oxford University Press, 2000

PS-FMB -204

1) Roitt’s Essential Immunology 13th Ed. –Wiley Blackwell
2) Kuby Immunology 6th Ed – W. H. Freeman and Company, New York Reference Books:
3) Immunology –Essential and Fundamental – SulbhaPathak, UrmiPalan, 3rd Ed. Capital Publishing Company (New Delhi-Kolkata)
4) Kuby Immunology 7th Ed – W. H. Freeman and Company, New York
5) Immunology – An Introduction 4th Ed – Tizard 5. Elements of Immunology- Fahim Halim Khan –Pearson Education
6) Medical Laboratory Technology - Kanai Mukherjee vol.
7) Current Published papers on recent advances to be referred.

8) Textbook of clinical trials- editors David Machim, Simson Day & Sylvan Green-John Wiley & Sons.
9) Management of Data in Clinical Trials- Eleanor McFadden M.A. - John Wiley & Sons.
10) Clinical Trials- Issues and Approaches- Edited by Stanley H. Shapiro, Thomas A. LouisMarcel Dekker Inc
11) Textbook of Medical laboratory technology- by P B Godkar,1994, Bhalani Publishers
12) Immunology-Essential &Fundamental-SulbhaPhatak&Urmi Palan-3rd edition.2012, Capital Publishing Company.
13) Mannfred A. Holliger, (2008), Introduction to pharmacology, 3rd Ed., CRC Press
14) Micheles P. S., Y. L. Khmelnitsley, J. S. Dordick and D. S. Clark, (1998), Combinatorial Biocatalysis, A Natural Approach to Drug Discovery, Trends in Biotechnol. 16, 197.
15) OsolArther (1975) Remington's Pharmaceutical Sciences, 15th Ed., Mack Pub. Co., Pennsylvania.
16) Sylvie E. Blondelle, Enrique Pe´Rez-Paya, And Richard A. Houghten, (1996), Synthetic Combinatorial Libraries: Novel Discovery Strategy for Identification of Antimicrobial Agents, Antimicrobial Agents and Chemotherapy, 1067–1071
17) Vyas S. P and Dixit V. R. (2002), Pharmaceutical Biotechnology, CBS Publishers and Distributors, New Delhi
18) Freshney R. Ian, (2005), Culture of Animal Cells: A Manual of Basic Technique, 5th Ed., John Wiley & Sons, Inc.
19) GangalSudha and SontakkeShubhangi, 2013, Textbook of Basic and Clinical Immunology Paperback, University Press, India
20) . House Robert V., (1998), Therapeutic Manipulation of Cytokines, Biotechnology and Safety Assessment, 2nd Ed., Taylor & Francis, 81-105
21) Saeed AF, Wang R, Ling S, Wang S. Antibody Engineering for Pursuing a Healthier Future. Front Microbiol. 2017;8:495. Published 2017 Mar 28. doi:10.3389/fmicb.2017.00495
22) https://www.elveflow.com/microfluidic-reviews/general-microfluidics/introduction-to-lab-on-a-chip-2015-review-history-and-future/