SOPHIA COLLEGE
(Autonomous)

Affiliated to

University Of Mumbai

Syllabus
Program: M.Sc.
Class: M.Sc.-I
Course: MICROBIOLOGY

With effect from the academic year 2020-2021

Theory: Semester 1

Course code	Unit	Topic Headings	Credits	Total number of lectures
SMSMCB101 Virology and Cell Biology-I	1	Bacteriophages	4	15
	2	Plant Viruses		15
	3	Plasma membrane, Mitochondria and Chloroplast		15
	4	Endomembrane system		15
SMSMCB102 Genetics-I	1	DNA replication and Gene expression	4	15
	2	Recombination, Mutation and Repair		15
	3	Regulation of gene expression in bacteria		15
	4	Eukaryotic gene regulation and Epigenetics		15
SMSMCB103 Microbial Biochemistry	1	Aqueous Solutions and Acid-Base Chemistry	4	15
	2	Analytical Biochemistry		15
	3	Bioorganic Molecules		15
	4	Signaling and stress		15
SMSMCB104 Medical Microbiology and Immunology	1	Advances in Medical Microbiology part 1	4	15
	2	Advances in Medical Microbiology part 2		15
	3	Immune system and health I		15
	4	Immune system and health II		15

Practicals: Semester 1 SMSMCBP1

Course code	Title	Credits
SMSMCBP101	Virology and Cell Biology-I	2
SMSMCBP102	Genetics-I	2
SMSMCBP103	Microbial Biochemistry	2
SMSMCBP104	Medical Microbiology and Immunology	2

Semester 1

SMSMCB101- Virology and Cell Biology-I

Learning Objectives

- To understand the replication and regulation of transcription of bacteriophages.
- To learn life cycle of plant viruses and agents that infect plants such as Viroids.
- To achieve the understanding of cell biology of eukaryotic microorganisms being Microbiology students.
- To understand cell biology of humans and animals in order to understand the life cycle of human and animal viruses.

Learning Outcomes

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

- explain replication and regulation of gene expression of different bacteriophages.
- explain the structure, replication and life cycle of specific plant viruses and prevention and control of plant viral infections.
- explain role of membrane proteins and transport, mitochondrial ETC and ATP synthesis and chloroplast in eukaryotes.
- explain eukaryotic nuclear pore complex, Endoplasmic reticulum, Golgi complex and vesicle transport. They should also be able to elaborate vacuoles of eukaryotic microorganisms such as fungi, yeast (*Saccharomyces cerevisiae*) algae and amoeba.
- link cell biology concepts such as endocytosis, clathrin coated vesicles, transport of mRNAs from nucleus to cytoplasm with life cycle of human viruses which they will learn in semester 2.

COURSE CODE SMSMCB 101	UNIT	TITLE Virology and Cell Biology-I	Number Of Lectures
	I	**Bacteriophages**	**15**
		Students to revise general properties, structure of bacteriophages and stages in a lytic life cycle of a typical phage	
		1.1 *E.coli* Phage T7: Genetic organization, regulation of transcription, DNA replication and maturation (03 L)	
		1.2 *E.coli* Phage φX174: Replication, transcription, packaging (02 L)	
		1.3 Filamentous DNA phages- M13: Attachment and entry, replication, assembly and release (02 L)	
		1.4 Single stranded RNA phages MS-2 and Qβ: Genetic organization and life cycle (01L)	
		1.5 Lambda phage: lytic and lysogenic cycle (05 L)	
		1.6 Bacteriophage Mu: Properties, Genetic organization and replication (02 L)	
	II	**Plant Viruses**	**15**
		2.1 Viruses causing plant diseases: History, transmission, symptoms, detection, prevention and control (02 L)	
		2.2 Structure of plant viruses (01L)	
		2.3 Life cycles- overview (01L)	
		2.4 Tobacco Mosaic Virus- Life cycle, host range, transmission, symptoms, diagnosis and control (04 L)	
		2.5 Citrus Tristeza Virus (01L)	
		2.6 Applications of plant viruses (01L)	
		2.7 RNA interference (02 L)	
		2.8 Plant satellites (01L)	
		2.9 Viroids (02 L)	
	III	**Plasma membrane, Mitochondria and Chloroplast**	**15**
		Students to revise basic properties of cells, different classes of cells and functions of plasma membrane	
		3.1 Plasma membrane (06 L)	

	a. Chemical composition of membranes- (in brief) i. Membrane lipids (phosphoglycerides, sphingolipids, cholesterol) ii. carbohydrates b. Structure and functions of membrane proteins - i. Integral membrane proteins ii. peripheral membrane proteins iii. lipid anchored membrane proteins c. Membrane lipids and fluidity d. Movement of substances across cell membranes i. Diffusion of substances through membranes Voltage-gated channels, Ligand-gated channels, Mechano-gated channels ii. Facilitated diffusion iii. Active transport	
	3.2 Mitochondria (06 L) a. Mitochondrial structure and function- membrane and matrix b. Oxidative metabolism in the mitochondrion c. Role of mitochondria in the formation of ATP i. Electron transport ii. types of electron carriers d. Establishment of proton motive force e. Machinery for ATP formation i. Structure of ATP synthase ii. basis of ATP formation, Rotational catalysis f. Peroxisomes	
	3.3 Chloroplast (03 L) a. Chloroplast structure and function b. Photosynthetic metabolism c. Photosynthetic pigments d. Photosynthetic units and reaction centers i. PSII operations ii. PSI operations e. Photophosphorylation	
IV	**Endomembrane system**	**15**
	a. Nuclear envelope b. Structure of the Nuclear Pore Complex and its role in Nucleocytoplasmic exchange	

	c. The endoplasmic reticulum d. The smooth endoplasmic reticulum e. Functions of the rough endoplasmic reticulum- synthesis and processing of proteins f. The Golgi complex g. Types of vesicle transport and their functions- Cop II-coated vesicles, Cop I-coated vesicles h. Fungal vacuoles, comparison with lysosomes i. Contractile Vacuoles in algae and amoeba j. Vacuoles in yeast *Saccharomyces cerevisiae* k. Endocytic pathway	

SMSMCB102- Genetics-I

Learning objectives

- To understand co-ordination of DNA replication and septum formation in bacteria.
- To understand molecular details of gene expression and its regulation in bacteria and eukaryotes.
- To learn recombination at the molecular level in bacteria and eukaryotic microorganisms such as yeast.
- To learn complementation test and fine structure mapping in bacteriophages.
- To learn recombination repair mechanisms in *E.coli* and eukaryotes.
- To learn epigenetic regulation of genes in eukaryotes.

Learning outcomes

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

- understand concepts of molecular genetics.
- explain role of bacterial proteins in septum formation and segregation of chromosomes and also in partitioning of plasmids.
- explain molecular details of transcription, RNA processing and splicing and translation.
- elaborate different models of recombination, role of proteins in bacterial and eukaryotic recombination and mating type switching in *Saccharomyces cerevisiae.*
- explain complementation test and fine structure mapping and their significance.
- explain significance of recombination repair mechanisms in *E.coli* and eukaryotes.
- explain bacterial operons, mutations affecting regulation of gene expression, attenuation, antisense RNA and regulation during sporulation in *Bacillus.*
- explain eukaryotic gene regulation and epigenetics.

COURSE CODE SMSMCB 102	UNIT	TITLE Genetics-I	Number Of Lectures
	I	**DNA replication and Gene expression**	**15**
		1.1 Replication and Genetics of Cell division in bacteria (05 L) a. Replication and cell cycle b. Septum formation in bacteria c. Function of FtsZ, MinCD and MinE d. Partitioning of Chromosomes e. Partitioning of single copy plasmids	
		1.2 Gene expression (10 L) a. Transcription i. Bacterial Transcription ii. Eukaryotic Transcription b. RNA molecules and processing i. Messenger RNA- Structure, processing, addition of the 5' Cap, addition of the Poly (A) tail, RNA splicing, self splicing introns, introns of T4 bacteriophage, Alternative processing pathways, RNA editing ii. Transfer RNA- Structure of transfer RNA, tRNA gene structure and processing iii. Ribosomal RNA- Structure of the ribosome, rRNA gene structure and processing c. Translation i. The process of translation- The binding of amino acids to transfer RNAs ii. The Initiation, elongation and termination of translation d. The posttranslational modifications of proteins	
	II	**Recombination, Mutation and Repair**	**15**
		2.1 Recombination (09 L) a. Holliday model b. DSB repair model	

		c. Homologous recombination machines in prokaryotes- RecBCD, RecA, RuvA, RuvB and RuvC d. Homologous recombination in eukaryotes and proteins involved in the same *e.* Mating type switching in *Saccharomyces cerevisiae* f. Concept of linkage	
		2.2 DNA Mutations (03 L) ***(Students to revise the entire topic of Mutations from T.Y.B.Sc.)*** a. Mutagens- Base analogs (5-bromouracil, 2-aminopurine), Alkylating agents, Intercalating agents b. Complementation test and fine structure mapping	
		2.3 DNA Repair (03 L) a. Recombination repair in *E. coli* b. NHEJ pathway	
	III	**Regulation of gene expression in bacteria**	**15**
		3.1 Regulation of gene expression in bacteria (15 L) a. Operons i. The *lac* operon of *E. coli* –Experimental evidence for the regulation of *lac* genes, mutations in the protein-coding genes, mutations affecting the regulation of gene expression, operator mutations- $lacO^c$ mutations, *lacI* gene regulatory mutations, promoter mutations, positive control of the *lac* operon ii. The *ara* operon of *E. coli*: Positive and negative control iii. The *trp* operon of *E. coli*- Attenuation iv. The *hut* operon b. Antisense RNA c. Riboswitches d. Sigma factor switching- Sporulation in *Bacillus subtilis*	

IV	**Eukaryotic gene regulation and Epigenetics**	**15**
	4.1 Eukaryotic gene regulation (15 L) a. Gene regulation in Eukaryotes- i. Changes in chromatin structure ii. Regulation of transcription factors and activators iii. RNA Processing- Examples- SV40, sex differentiation in Drosophila, Degradation of RNA, RNA interference (briefly) iv. Processes that affect Translation, modification of proteins. b. Epigenetic regulation- i. DNA methylation and demethylation, ii. Histone modifications, Acetylation, phosphorylation, Ubiquitinylation, Poly ADP Ribosylation, iii. Heterochromatin, histone variants, iv. Nucleosome v. Long non-coding RNA, alternate splicing, vi. Mammalian development, dosage compensation and genomic imprinting (disorders/ diseases)	

SMSMCB103- Microbial Biochemistry

Learning Objectives

- To understand the chemistry underlying the preparation of solutions, buffers etc.
- To understand the purification of macromolecules and learn their properties using different instrumental techniques.
- To understand the structure and function of macromolecules: proteins, carbohydrates, lipids.
- To understand the signaling pathways in bacteria under environmental stresses.

Learning Outcomes

At the end of the course the student should be able to

- prepare solutions and buffers of specific strength.
- apply purification techniques and characterize molecules.
- explain the correlation between structure and functions of macromolecules.
- explain the relationship between stress and signaling pathways for survival in bacteria.

COURSE CODE SMSMCB 103	UNIT	TITLE Microbial Biochemistry	Number Of Lectures
	I	**Aqueous Solutions and Acid-Base Chemistry**	**15**
		1.1 Various units of expressing and inter-converting concentration of solutions: molarity, moles, normality, osmolarity, molality, mole fraction	2
		1.2 Bronsted Concept of conjugate acid- conjugate base pairs, ionization of solutions, pH, titration curves	3
		1.3 Buffers: preparation, action and their use in Biology Henderson-Hasselbalch equation, buffer capacity	3
		1.4 Polyprotic acids, amphoteric salts, ionic strength of solutions	3
		1.5 Problem solving under all heads	4
	II	**Analytical Biochemistry**	**15**
		2.1 Determination of molecular weight, purity, length and volume of organic compounds	2
		2.2 General methods of extraction: salting out proteins, use of organic solvents	1
		2.3 Purification using chromatographic techniques	2
		2.4 Mass determination using Ultracentrifugation and GC-MS	2
		2.5 Different types of mass spectrometry and surface plasma resonance methods	2
		2.6 UV/visible, fluorescence, circular dichroism, NMR and ESR spectroscopy	3
		2.7 Determination of structure using X-ray diffraction and NMR	2
		2.8 Radiolabeling techniques: Properties of different types of radioisotopes normally used in biology, their detection and measurement; incorporation of radioisotopes in biological tissues and cells, molecular imaging of radioactive material, safety guidelines.	1
	III	**Bioorganic Molecules**	**15**
		3.1 Amino acids: Classification and stereochemistry, properties, biochemical information from amino acid sequence, derivative, ionization	2
		3.2 Structure and function of Proteins: Structure of peptide bond, stability of peptide bond, Ramachandran plot	3
		3.3 Protein structure, factors determining secondary, tertiary structures: amino acid sequence,	3

		thermodynamics of folding, role of disulfide bonds, dynamics of globular protein folding, chaperonins. Protein folding diseases: amyloid diseases and prions.	
		3.4 Motifs and domains, protein families, protein stability, prediction of secondary and tertiary structure, protein-protein interactions	2
		3.5 Glycobiology: Carbohydrates, stability of glycosidic bond, glycoconjugates, proteoglycans, glycoproteins, glycolipids, homopolysaccharide folding, functions of oligosaccharides	2
		3.6 Lipids: Classification, structure of lipids in membranes- glycerolipids, ether lipids, galactolipids, sulfolipids, lipids in archaebacteria, sphingolipids, terpenes, isoprenoids, Functions of lipids- signals, cofactors, pigments	3
	IV	**Signaling and stress**	**15**
		4.1 Introduction to two-component signaling systems: i. Response by facultative anaerobes to anaerobiosis, nitrate and nitrite, nitrogen and inorganic phosphate supply ii. Synthesis of virulence factors in response to temperature, pH, nutrient, osmolarity and quorum sensors, chemotaxis, photoresponses, aerotaxis	5
		4.2 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	4
		4.3 Bacterial response to environmental stress- heat-shock response, repairing damaged DNA, the SOS response, oxidative stress	2
		4.4 Bacterial development and quorum sensing: Myxobacteria, Caulobacter, bioluminescence, systems similar to LuxR/LuxI in non-luminescent bacteria, Biofilm development.	4

SMSMCB104-Medical Microbiology and Immunology

Learning Objectives

- Keeping in mind the threat of emerging and re-emerging diseases that the world is facing today, students will be taught emerging and re-emerging diseases as per the World Health Organization list, published in 2015 and also those most prevalent in Asian countries.
- They will also be taught the modes of transmission, pathogenesis, clinical manifestation, lab diagnosis, containment procedures to prevent unintentional exposure to bio hazardous agents and treatment of the emerging and re-emerging diseases.
- To understand the mechanism of the inflammation process and role of leukocytes, chemokines and other mediators in this process.
- To understand biological activity of cytokines, the structure of cytokines and their receptors, and therapeutic uses of cytokines or their receptors.
- To understand the immune responses to infectious diseases caused by viruses, bacteria, protozoa, and helminths.
- To understand the importance of gut flora in health and disease.

Learning Outcomes

At the end of the course, students should be able to:

- understand modes of transmission, pathogenesis, clinical manifestation, lab diagnosis, containment procedures to prevent unintentional exposure to bio hazardous agents and treatment of the emerging and re-emerging diseases.
- understand the process of inflammation and the key mediators involved in this process.
- the role of cytokine in different immune processes; cytokine profile of TH1 and TH2 and TH17 subsets and their therapeutic uses.
- the innate and adaptive immune responses to infectious diseases caused by viruses, bacteria, protozoa, and helminths.
- the changes in gut flora with age, the techniques used to study gut flora and importance of gut microflora in health and disease.

COURSE CODE SMSMCB 104	UNIT	TITLE Medical Microbiology and Immunology	Number Of Lectures
	I	**Advances in Medical Microbiology part –I**	**15**
		1.1 Bacterial Emerging and Re-emerging Diseases	
		Detailed Study: Common factors of emerging and reemerging diseases and their causes, Etiology, Transmission, Pathogenesis, Clinical manifestation, Lab diagnosis, Prevention and Treatment.	
		a. Listeriosis	
		b. VRE (Vancomycin Resistant Enterococci)	
		c. Leptospirosis	
		d. Drug resistant Tuberculosis	
		e. Conditions caused by *Helicobactor pylori*, *Campylobacter* and MRSA	
	II	**Advances in Medical Microbiology part –I**	**15**
		2.1 Viral Emerging and Re-emerging Diseases	
		Detailed Study: Common factors of emerging and reemerging diseases and their causes, Etiology, Transmission, Pathogenesis, Clinical manifestation, Lab diagnosis, Containment procedures to prevent unintentional exposure to biohazardous agents and Treatment.	
		a. SARS	
		b. Chickungunya	
		c. Swine flu	
		d. Zikavirus	
		e. Dengue	
		f. Japanese Encephalitis	
		g. Nipah	
		h. Ebola	
		i. COVID-19	
	III	**Immune system and health I**	**15**
		3.1 Immunity to infection Leukocyte migration and inflammation a. Lymphocyte Recirculation b. Cell-Adhesion Molecules c. Neutrophil Extravasation	

	d. Lymphocyte Extravasation e. Chemokines—Key Mediators of Inflammation f. Other Mediators of Inflammation g. The Inflammatory Process h. Anti-Inflammatory Agents	
	3.2 Cytokines a. Properties of Cytokines b. Cytokine Receptors c. Cytokine Antagonists d. Cytokine Secretion by TH1 and TH2 & TH17 Subsets e. Cytokine-Related Diseases f. Therapeutic Uses of Cytokines and Their Receptors g. Cytokines in Hematopoiesis	
IV	**Immune system and health II**	**15**
	4.1 Adversial strategies during infection a. Immunity to extracellular bacteria b. Immunity to Intracellular bacteria c. Immunity to Viral infection d. Immunity to Fungi e. Immunity to Parasitic infection **4.2 Gut Flora in Health and Disease** a. Changes in gut microflora with age b. Techniques for the study of gut microbiome c. The interplay between nutrition on gut flora d. Effects of gut flora on health and well-being e. Manipulation of the gut microbiome	

Practicals- Semester 1 SMSMCBP1

SMSMCBP101 Virology and Cell Biology-I

Sr. No	Name of the experiment
1	Enumeration of coliphages by plaque assay.
2	Study of one step growth curve of T4 bacteriophage.
3	Study of lysogeny in *E. coli.*
4	Assignment/Activity on plant viruses/ viroids.
5	Study of cell membrane integrity using uptake of neutral red.
6	Isolation of mitochondria from the cell.
7	Isolation of chloroplasts.

SMSMCBP102 Genetics-I

Sr. No	Name of the experiment
1	Separation of plasmid or genomic DNA using agarose gel electrophoresis.
2	Bacterial conjugation.
3	UV mutagenesis.
4	Penicillin enrichment technique.
5	Ames test.
6	β- galactosidase assay.
7	Problems on *lac* operon.

SMSMCBP103 Microbial Biochemistry

Sr. No	Name of the experiment
1	Preparation of buffers.
2	Determination of pK and pI value for an amino acid.
3	Extraction of total lipids.
4	Isolation of cholesterol and lecithin from egg yolk.
5	Identification of fatty acids and other lipids by TLC.
6	Determination of degree of unsaturation of fats and oils.
7	Isolation of lactose from bovine milk.
8	Estimation of total sugars by phenol-sulphuric acid method.
9	Isolation of glutamic acid from gluten.
10	Determination of molar absorption coefficient (ε) of l-tyrosine.
11	Determination of the isoelectric point of the given protein.
12	Estimation of polyphenols/ tannins by Folin-Denis method.
13	Adaptation of *E.coli* to anaerobiosis.
14	Chemotaxis of *Pseudomonas.*
15	Effect of temperature and water activity on swarming of *Proteus.*
16	Visit to any centre/research lab for Demonstration of HPLC / GC.

SMSMCBP104 Medical Microbiology and Immunology

Sr. No	Name of the experiment
1	Group project: a) How can governments stop the happening of pandemics? OR b) Application of bioinformatics in medical sciences: Finding a drug suitable for an emerging disease (refer NCBI website).
2	Problem solving exercises in medical microbiology based on diseases caused by- Chikungunya, *Helicobacter*, Leptospirosis, Drug resistant TB, *Campylobacter*, MRSA, Swine flu, Zikavirus, Dengue, Nipah, Ebola or Japanese encephalitis, SARS and COVID-19.
3	Acid fast staining for *M. tuberculosis*.
4	Diagnosis for *Helicobacter pylori:* (Demonstration) Urea breath test and test for urease production in biopsy samples.
5	Diagnosis of VRE: Using isolation, biochemical tests and AST.
6	Diagnosis of dengue: Use of NS1 antigen kit.
7	Diagnosis for Swine flu-H1N1: Hemagglutination & Hemagglutination inhibition test.
8	Diagnosis for Leptospirosis: Spirochaete staining.
9	RT-PCR for diagnosing COVID 19 or any other disease (demonstration).
10	ELISA (Demonstration): A diagnostic method for most viral infections.
11	To observe and write about any one type of test to detect resistant *Mycobacteria*: Bactec MGIT 960 system /Reverse line blot assay/X-pert MTB or RIF assay/Line Probe assay. (Can visit any hospital)
12	Study of virulence factors: a) Phagocytosis b) Phagocytic index
13	Collection of human blood & separation of mononuclear cells by Ficoll hypaque density gradient centrifugation.
14	Trypan blue, mononuclear cells viability assay.

References – Semester 1

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Practical:

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Theory: Semester 2

Course code	Unit	Topic Headings	Credits	Total number of lectures
SMSMCB201 Virology and Cell Biology-II	1	Human Viruses	4	15
	2	Emerging and re-emerging viruses, Tumor viruses and Prions		15
	3	Cytoskeleton, Cellular reproduction and Development of multicellular organisms		15
	4	Signaling, Communication and Programmed cell death in microorganisms		15
SMSMCB202 Genetics-II	1	Mendelian Genetics and Population Genetics	4	15
	2	Evolutionary Genetics, Transposable genetic elements and Cancer		15
	3	Techniques used in Genetics		15
	4	Bioinformatics and Functional Genomics		15
SMSMCB203 Microbial Biochemistry	1	Biosynthesis and Molecular Physiology	4	15
	2	Enzymology		15
	3	Metabolism of one & two carbon compounds		15
	4	Microbial Degradation of xenobiotics		15
SMSMCB204 Medical Microbiology and Immunology	1	Epidemiology of Infectious Diseases	4	15
	2	Clinical Research in Medical Microbiology		15
	3	Clinical Immunology I		15
	4	Clinical Immunology II		15

Practicals: Semester 2 SMSMCBP2

Course code	Title	Credits
SMSMCBP201	Virology and Cell Biology-II	2
SMSMCBP202	Genetics –II	2
SMSMCBP203	Microbial Biochemistry	2
SMSMCBP204	Medical Microbiology and Immunology	2

Semester 2

SMSMCB201- Virology and Cell Biology-II

Learning Objectives

- To understand molecular biology and life cycle of human viruses as per Baltimore classification scheme.
- To understand emergence and re-emergence of viruses, their role in cancer and working with them in the research laboratory.
- To learn Prions and genetic experiments performed.
- To understand cytoskeletal elements and their functions.
- To learn eukaryotic cell cycle, mitosis and meiosis emphasizing more on yeasts *Saccharomyces cerevisiae and mold Neurospora crassa.*
- To learn Development of multicellular organisms such as *Drosophila melanogaster.*
- To learn signalling and communication in eukaryotic microorganisms such as fungi and yeast *Candida albicans.*
- To learn programmed cell death in bacteria and yeasts.

Learning Outcomes

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

- explain replication and life cycle of different viruses, mechanism of retroviruses induced tumors, DNA tumor viruses, oncolytic viruses and Prion only hypothesis.
- explain the structure and functions of Microtubules, Intermediate filaments and Microfilaments.
- explain the cell cycle and checkpoints and their significance, stages of mitosis and meiosis and life cycle of mold *Neurospora crassa.* They should be able to connect the cellular reproduction with Paper 2 topics such as Mendelian Genetics, Extensions of the same and Cancer.
- explain the development of model organism *Drosophila melanogaster* and role of different genes in its development.
- elaborate cell signalling and signal transduction, MAP kinase pathway in fungi, Ras signaling in yeast *Candida albicans.*
- explain programmed cell death in *E.coli,* during sporulation in *Bacillus subtilis,* in *Myxococcus xanthus* and programmed cell death and aging in *Saccharomyces cerevisiae.*

COURSE CODE SMSMCB 201	UNIT	TITLE Virology and Cell Biology-II	Number Of Lectures
	I	**Human Viruses**	**15**
		Students to revise Baltimore classification scheme	
		Structure, Replication and Life cycle of following viruses	
		1.1 Baltimore class 1 viruses a. Poxviruses (Variola major and Vaccinia) (02 L) b. Herpesviruses (02 L)	
		1.2 Baltimore class 2 viruses- Parvovirus (01L)	
		1.3 Baltimore class 3 viruses- Rotavirus (02 L)	
		1.4 Baltimore class 4 viruses- Rhinovirus (02 L)	
		1.5 Baltimore class 5 viruses a. Rabies virus (01L) b. Measles virus (02 L)	
		1.6 Baltimore class 6 viruses- Students to revise HIV from T.Y.B.Sc. (Class activity)- (01L)	
		1.7 Baltimore class 7 viruses- Hepatitis B virus (02 L)	
	II	**Emerging and re-emerging viruses, Tumor viruses and Prions**	**15**
		2.1 Emerging and reemerging viruses - Factors contributing to emergence and re-emergence, Structure and Life cycle (06 L) a. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) b. West Nile Virus (WNV) c. Dengue virus	
		2.2 Tumor viruses (04 L) ***Students to revise important definitions related to Cancer and characteristics of transformed cells*** a. Molecular mechanisms of virally induced tumor formation by RNA tumor viruses (Retroviruses) b. DNA tumor viruses - Human Papilloma Virus, Adenoviruses, Simian Virus- 40 c. Oncolytic viruses	

		2.3 Prions (02 L) a. History, case studies b. PRNP gene, Prion only hypothesis c. Biochemical analysis of the prion amino acid sequence d. Genetic Research and experiments with knockout mice	
		2.4 Working with viruses in the research laboratory (03 L)	
	III	**Cytoskeleton, Cellular reproduction and Development of multicellular organisms**	**15**
		3.1 Cytoskeleton (08 L) a. Overview of the major functions of the cytoskeleton b. Microtubules i. Structure and composition ii. Microtubule-associated proteins iii. Motor proteins - kinesins, cytoplasmic dynein iv. Microtubule-organizing centers (MTOCs) v. The dynamic properties of microtubules c. Intermediate filaments i. Intermediate filament assembly and disassembly ii. Types and functions d. Microfilaments i. Microfilament assembly and disassembly ii. Myosin: the molecular motor of actin filaments e. Cytoskeletal elements in bacteria	
		3.2 Cellular Reproduction (05 L) a. The cell cycle b. Control of the cell cycle c. Mitosis d. Meiosis e. Life cycle of mold *Neurospora crassa*	
		3.3 Development of Multicellular Organisms (02 L) a. Genetics of Pattern formation in *Drosophila* i. Egg-polarity genes	

	ii. Segmentation genes iii. Homeotic genes b. Homeobox genes in other organisms	
IV	**Signalling, Communication and Programmed cell death in microorganisms**	**15**
	4.1 Signalling, communication and programmed cell death in microorganisms (15 L) a. The basic elements of cell signalling systems b. G protein-coupled receptors and signal transduction by them c. MAP Kinase Pathway in fungi *d.* Ras signalling in pathogenic yeast *Candida albicans* e. Communication in Fungi- Messengers- Peptides, alcohols, lipids and volatile compounds f. Programmed cell death in bacteria- *i.* Programmed cell death in *E.coli* ii. Plasmid addiction systems iii. Lysis of the mother cell during sporulation of *Bacillus subtilis* iv. Lysis of vegetative cells in fruiting body formation of *Myxococcus xanthus* g. Programmed cell death and aging in *Saccharomyces cerevisiae*	

SMSMCB202- Genetics-II

Learning objectives

- To understand Mendelian genetics, principles of inheritance and extensions of and deviations from Mendelian genetics.
- To introduce students to concepts and principles associated with population genetics and evolutionary genetics.
- To understand the genetic basis of cancer.
- To learn about the Transposable genetic element in prokaryotes and eukaryotes.
- To learn the techniques used for study of genetics.
- To learn basics and applications of bioinformatics.

Learning outcomes

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

- explain the Mendelian principles and acquire knowledge of its extensions and deviations.
- understand the principles of population genetics and evolutionary genetics.
- understand the genetic basis of cancer.
- elaborate on the Transposable genetic elements in prokaryotes and eukaryotes.
- elaborate on the techniques used for study of genetics.
- understand the basics of computational biology and applications of bioinformatics.

COURSE CODE SMSMCB 202	UNIT	TITLE Genetics-II	Number Of Lectures
	I	**Mendelian Genetics and Population Genetics**	**15**
		1.1 Mendelian Genetics (03 L) a. Mendel's experimental design b. Monohybrid crosses and Mendel's principle of Segregation i. Branch diagram of monohybrid crosses ii. Use of testcrosses c. Dihybrid crosses and Mendel's principle of Independent Assortment i. Branch diagram of dihybrid crosses d. Trihybrid crosses e. Mendelian genetics in Humans- Pedigree analysis (Only concept, No specific examples of human genetic traits)	
		1.2 Extensions of and Deviations from Mendelian Genetic Principles (06 L) a. Multiple Alleles b. Modification of dominance relationships i. Incomplete dominance ii. Codominance iii. Molecular explanations c. Essential genes and lethal alleles d. Gene expression and environment e. Epistasis i. Recessive epistasis ii. Dominant epistasis f. Extranuclear Inheritance (non-Mendelian) i. Extranuclear genomes ii. Rules of extranuclear inheritance iii. Examples of extranuclear inheritance	
		1.3 Population Genetics (06 L) a. Genotypic and allelic frequencies b. Calculation of genotypic and allelic frequencies for autosomal and X linked loci c. Hardy-Weinberg Law and calculation of genotypic frequency at Hardy Weinberg equilibrium d. Factors affecting genotypic and allelic frequencies e. Changes in genetics structure of populations (mutation, migration & gene flow, genetic drift and	

		natural selection) f. Measuring genetic variation	
	II	**Evolutionary Genetics, Transposable genetic elements and Cancer**	**15**
		2.1 Evolutionary Genetics (04 L) a. Molecular Evolution i. Protein variation ii. DNA sequence variation iii. Molecular evolution of HIV in a Florida Dental Practice iv. Patterns of molecular variation v. Molecular clock vi. Evolution of drug resistance in *Mycobacterium tuberculosis*	
		2.2 Transposable genetic elements (05 L) a. Transposable elements in prokaryotes: An overview b. The medical significance of bacterial transposons c. Transposable elements in eukaryotes i. Ac and Ds elements in Maize ii. P elements and hybrid dysgenesis in Drosophila iii. Mariner, an ancient and widespread transposon d. Retrotransposons i. Retrovirus like elements ii. Retroposons e. The genetic and evolutionary significance of transposable elements i. Transposons as mutagens ii. Transposons and genome organization	
		2.3 Genetic basis of cancer (06 L) a. Cancer- Introduction b. Mutations in different types of genes c. Change in chromosome number and structure, d. Changes in DNA methylation e. Sequential mutations	
	III	**Techniques used in Genetics**	**15**
		3.1 Techniques used in studying Genetics (15 L)	

	a. Microarrays b. Positional cloning c. RFLP d. Genetic fingerprinting, e. High resolution mapping f. Autoradiography g. Nucleic acid hybridization h. DNA typing with their forensic applications, i. DNA sequencing (Sanger's chain termination method, Pyrosequencing), j. Restriction mapping k. Site directed mutagenesis l. Mapping and quantifying transcripts (S1 mapping, primer extension, run-off transcription) m. Measuring transcription rates in vivo (Nuclear run – on transcription, reporter gene transcription), n. Assaying DNA –protein interactions (Filter binding, gel mobility shift, DNase and DMS foot printing.)	
IV	**Bioinformatics and Functional Genomics**	**15**
	4.1Bioinformatics (09 L) a. Introduction to bioinformatics, scope and applications b. Databases c. Sequence alignment, dynamic programming: the Needleman and Wunsch Algorithm d. Prediction of genes and annotation methods e. Phylogenetic analysis f. Protein classification and structure prediction g. Structure visualization h. Packages for genomic analysis (EMBOSS) i. Introduction to Linux and Perl	
	4.2 Functional Genomics (06 L) a. Introduction to Genomics (Structural, Functional and Comparative) b. Genome projects c. Gene disruption knock outs d. Developmental regulation using DNA chips e. CRISPR Cas gene editing with case studies	

SMSMCB203- Microbial Biochemistry

Learning Objectives

- To understand the biosynthesis of macromolecules and also to understand physiology of autotrophs.
- To understand enzyme kinetics, catalysis and inhibition.
- To understand regulation of pathways using enzymes.
- To understand metabolism of one carbon compounds.
- To understand microbial degradation of xenobiotics.

Learning Outcomes

At the end of the course the student should be able to

- write the metabolic pathways for the biosynthesis of macromolecules.
- explain assimilation of nitrogen and pathways involved therein.
- explain the mechanism of action of an enzyme on a substrate and also different types of inhibitions.
- explain the mechanism of regulation of pathways using enzymes.
- explain the synthesis of precursors and energy using one or two carbon sources.
- explain the pathways involved in biodegradation of xenobiotics and its importance.

COURSE CODE SMSMCB203	UNIT	TITLE Microbial Biochemistry	Number Of Lectures
	I	**Biosynthesis & Molecular physiology**	**15**
		1.1 Nitrogen metabolism: Biosynthesis of five families of amino acids and histidine, Biosynthesis of purine and pyrimidine bases	4
		1.2 Lipid biosynthesis: Synthesis of storage lipids: Fatty acids, triacylglycerols, Synthesis of membrane lipids: Glycerophospholipids, sphingolipids, sterols	2
		1.3 Vitamins: Fat soluble, water soluble and coenzyme form: functions and biosynthesis	2
		1.4 Antibiotics: Biosynthesis, mode of action, regulation, genetics, hybrid antibiotics	1
		1.5 Physiology of autotrophs & anaerobic respiration: autotrophic CO_2 fixation, hydrogen bacteria, methanogens. Nitrifying bacteria, sulphur bacteria, iron bacteria. Synthesis of carbohydrates in plants C_3, C_4 and CAM and bacteria **1.6** Calvin cycle and its regulation	5
		1.7 Biochemistry of biological nitrogen fixation, properties of nitrogenase and its regulation, Ammonia assimilation with respect to glutamine synthetase, glutamate dehydrogenase, glutamate synthetase, their properties and regulation.	1
	II	**Enzymology**	**15**
		2.1 Discovery of enzymes, terminology, basic aspects of kinetics of enzyme catalyzed reactions: Michaelis-Menten, Lineweaver-Burk equation derivation and plots. Kinetic parameters used to compare enzyme activities. Problem solving on all subtopics	2
		2.2 Mechanisms of enzyme catalysis: General acid-base, Covalent and Metal Ion catalysis **2.3** Example of enzymatic reactions: Chymotrypsin	5
		2.4 Enzyme inhibition -Reversible inhibition: a) Competitive inhibition b) Uncompetitive inhibition c) Mixed inhibition -Irreversible inhibition and Suicide inactivators HIV enzyme inhibitors, Nerve gas - catalytic antibodies Problem solving on all subtopics	3
		2.5 Regulatory enzymes: Allosteric enzymes- General properties, mechanism and kinetics, Two themes of	3

		allosteric regulations: -Regulation by covalent modification, -Regulation by multienzyme complexes and multifunctional enzymes (the blood coagulation cascade)	
		2.6 Study of Enzyme action using X-ray crystallography, Bioorganic Mechanism of enzyme catalyzed reactions: Stereochemical aspect of inhibition by penicillin	2
	III	**Metabolism of one & two carbon compounds**	**15**
		Metabolism of one carbon compounds: **3.1** Methylotrophs: Oxidation of methane, methanol, methylamines. Carbon assimilation in methylotrophic bacteria and yeasts.	4
		3.2 Methanogens: Methanogenesis form H_2, CO_2, CH_3OH, HCOOH, methylamines. Energy coupling and biosynthesis in methanogenic bacteria.	3
		Metabolism of two carbon compounds **3.3** Acetate-TCA and Glyoxylate cycle, modified citric acid cycle, Carbon monoxide dehydrogenase pathway and disproportionation to Methane. Ethanol-acetic acid bacteria.	4
		3.4 Glyoxylate and glycollate-dicarboxylic acid cycle, glycerate Pathway, beta hydroxy aspartate pathway, Oxalate as carbon and energy source	4
	IV	**Microbial degradation of Xenobiotics**	**15**
		4.1 Degradation of aromatic and alicyclic compounds-important organisms, use of mixed cultures and manipulation of degradative genes, common pathways of aromatic degradation using KEGG Database and LCMS, aerobic and anaerobic degradation of aromatic compounds.	6
		4.2 Aromatic and heterocyclic compounds with economical and ecotoxicological significance (phenolic pesticides, pthallic acid esters, lignosulphonates, surfactants, dyes and aromatics released during combustion)	3
		4.3 Biotransformation of polycyclic aromatic hydrocarbons (PAHs)- Pathway for degradation of Naphthalene, phenanthralene, anthracene, alicyclic and higher aliphatic hydrocarbons, halogenated aliphatics, branched chain alkanes and alkenes.	4
		4.4 Biochemical mechanisms of pesticide detoxification	2

SMSMCB204- Medical Microbiology and Immunology

Learning Objectives:

- Students need to learn various principles of epidemiological studies.
- Measures of risk like mortality and morbidity frequency measures need to be discussed.
- All the various steps involved in public health surveillance need to be studied.
- An introduction to clinical research and new modern diagnostic methods is necessary.
- To study Type I, II, III and IV hypersensitive reactions as proposed by P. G. H. Gell and R. R. A. Coombs.
- To study the mechanisms of organ specific and systemic autoimmune diseases.
- To study the principles of transplantation immunology.
- To study primary and secondary immunodeficiency diseases.
- To study the malignant transformation of cells and the immune evasion mechanisms.
- To study the experimental vaccines in the developmental stages.

Learning Outcomes:

- Various epidemiological principles like herd immunity and control of epidemics will be studied. Students will also get the opportunity to develop Personal Protective Equipment (PPE) and explain its detailed use.
- Learning various measures of risks, students will learn how to do calculations on their own.
- Details of collecting, analyzing, interpreting, disseminating and interpreting data in public health surveillance will be studied.
- Students will understand clinical research trials and get the opportunity to see modern diagnostic methods like microarrays.
- Understand the mechanisms of type I, II, III and IV hypersensitivity.
- Understand the mechanism and treatment of organ specific and systemic autoimmune diseases.
- Understand the mechanism of graft rejection and the immune cells involved.
- Understand the mechanisms involved and treatment options of primary and secondary immunodeficiency diseases.
- Understand cancer initiation, promotion, and progression and the role of cancer immuno therapy.
- Understand the challenges faced in the development of newer vaccines.

COURSE CODE SMSMCB 204	UNIT	TITLE Medical Microbiology and Immunology	Number Of Lectures
	I	**Epidemiology of Infectious Diseases**	**15**
		1.1 Historical aspects-definition	
		1.2 Descriptive Epidemiology-aims and uses	
		1.3 Epidemiological Principles a. Herd immunity b. Carrier status c. Co-evolution of host-parasite d. Control of epidemics i) Methods directed against reservoir ii) Methods directed against transmission iii) Pathogen eradication	
		1.4 Measures of Risk a. Frequency measures b. Morbidity frequency measures c. Mortality frequency measures d. Natality(birth) measures e. Measures of association f. Measures of public health impact	
		1.5 Public Health Surveillance a. Purpose and characteristics b. Identifying health problems for surveillance c. Collecting data for surveillance d. Analyzing and interpreting data e. Disseminating data and interpretation f. Evaluating and improving surveillance	
	II	**Clinical Research and Modern Diagnostics**	**15**
		2.1 Introduction to Clinical Research a. What is a clinical trial, history, phases and need? b. Good Clinical practice Guidelines c. Ethical aspects of Clinical Research d. Regulatory Requirements in clinical research e. Clinical Research Methodologies, Statistics and Management f. Case studies	

		2.2 Modern Diagnostic Methods a. Advances in Molecular and Immunological Techniques b. Microarrays c. Advances in Fluorescence Technology	
	III	**Clinical immunology I**	**15**
		3.1 Hypersensitivity a. Gel and Coombs classification: Type I, II, III and IV hypersensitivity.	
		3.2 Autoimmune diseases a. Organ Specific Autoimmune Diseases b. Systemic Autoimmune Diseases c. Proposed Mechanisms for Induction of Autoimmunity d. Treatment of Autoimmune Diseases	
		3.3 Transplantation immunology a. Antigens Involved in Graft Rejection b. Allorecognition c. Graft Rejection-Role of APC's & Effector Cells d. Graft v/s Host Diseases e. Immuno Suppressive Therapies	
	IV	**Clinical immunology I**	**15**
		4.1 Immunodeficiency diseases a. Primary Immunodeficiency b. Defects in the Complement System c. Treatment Approaches for Immunodeficiency d. Secondary Immunodeficiency & AIDS	
		4.2 Cancer and immune system a. Cancer: Origin & Terminology b. Malignant Transformation of Cells c. Cancer Initiation, Promotion, and Progression d. Tumor Associated Antigens e. Oncogenes & Cancer Induction f. Immune evasion in cancer g. Cancer Immuno Therapy	
		4.3 Experimental vaccines in development a. Challenges faced b. HIV c. T.B. d. Malaria	

Practicals- Semester 2 SMSMCBP2

SMSMCBP201 Virology and Cell Biology-II

Sr. No	Name of the experiment
1	Visit to NIRRH or Haffkine research institute.
2	Demonstration - Egg inoculation and cultivating animal virus in embryonated egg.
3	Assignment on 'evolution/mutations of a human virus.'
4	Study of Mitosis.
5	Study of Meiosis.
6	Study of mold *Neurospora crassa.*
7	Sporulation and germination in *Bacillus subtilis.*
8	Student activity- Students will watch at least three videos on Apoptosis and construct a quiz based on the above.

SMSMCBP202 Genetics-II

Sr. No	Name of the experiment
1	Problems on Mendelian genetics.
2	Problems on Population genetics.
3	DNA Transformation.
4	Curing of plasmids.
5	Problems on restriction mapping.
6	Design of primer & PCR.
7	Bioinformatics practicals.
8	Online course related to any aspect of Genetics **OR** Workshop on Molecular Biology/Genetics in an institute **OR** One-week internship in a research laboratory doing research on Genetics.

SMSMCBP203 Microbial Biochemistry

Sr. No	Name of the experiment
1	Enrichment, isolation and identification of *Methylobacterium.*
2	Purification of an extracellular enzyme (β-amylase) by salting out and dialysis.
3	Enzyme kinetics- effect of enzyme, substrate concentration, pH, temperature and inhibitors on enzyme activity.
4	Demonstration of proteolytic activity.
5	Determination of glucose isomerase present in *Bacillus sp.*
6	Microbial degradation of polycyclic aromatic Hydrocarbons (PAHs) - enrichment, isolation and screening of bacteria.
7	PAH degradation studies.
8	Student Activity Student will present a research paper on microbial degradation of any one Xenobiotic compound highlighting the pathway, optimization and profiling of analyte.

SMSMCBP204 Medical Microbiology and Immunology

Sr. No	Name of the experiment
1	Group activity: Preparation and detailed explanation of the use of Personal Protective Equipment (PPE).
2	Case study for epidemiology of any diseases included in Sem I (Theory), students have to collect data and interpret. This can be done from Net or approaching NGOs like "SEHAT". Collection of data, criteria, methodology etc. Assignment to be submitted.
3	Students will have to submit an assignment on a clinical trial.
4	Educational visit to see either Microarrays or Advances in Fluorescence Technology (can go to Reliance Life Sciences Centre).
5	Problems on mortality/morbidity frequency measures.
6	Immunoelectrophoresis of human serum.
7	Major and Minor cross matching of blood.
8	Determination of ABO & Rh antibody titers.
9	SRID: For detection of immune deficiency and Complement deficiency.

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Modality of assessment

A. Theory- Internal assessment 40% **40 marks**

Sr. No	Evaluation type	Marks
1.	Test a. Choose the correct alternative- 05 marks - (any five out of eight) b. Answer in one or two sentences- 05 marks - (any five out of eight) c. Diagrammatically explain/Describe/Justify/Explain/ Differentiate between/HWY- 10 marks – (any two out of three)	20
2.	Power Point Presentation on any of the topics from the syllabus / Report writing / Assignment / Essay writing / Notes preparation	15
3.	Attendance	05

B. Theory- External examination – 60% **60 marks**

Semester end examination (SEE)

- The duration of the examination will be of 2.5 hours.
- The question paper will have 5 questions each of 12 marks.
- On each unit, there will be one question (subjective) and fifth one will be based on all four units (objective).
- All questions will be compulsory with internal choice within the questions.
- Question 5 will be subdivided into sub questions a, b and c.

Practical Examination: -

- There will be no internal examination for practicals.
- External (semester end practical examination): 50 Marks per paper/section

Overall Examination pattern

Semester 1

Course	SMSMCB101			SMSMCB102			SMSMCB103			SMSMCB104			Grand total
	In	Ex	T	In	Ex	T	In	Ex	T	In	Ex	T	
Theory	40	60	100	40	60	100	40	60	100	40	60	100	**400**
Practicals	-	50	50	-	50	50	-	50	50	-	50	50	**200**

Semester 2

Course	SMSMCB201			SMSMCB202			SMSMCB203			SMSMCB204			Grand total
	In	Ex	T	In	Ex	T	In	Ex	T	In	Ex	T	
Theory	40	60	100	40	60	100	40	60	100	40	60	100	**400**
Practicals	-	50	50	-	50	50	-	50	50	-	50	50	**200**