SOPHIA COLLEGE

(Autonomous)

Affiliated to

University Of Mumbai

Syllabus

Program: M.Sc.

Class: M.Sc.-I

Course: MICROBIOLOGY

With effect from the academic year 2023-2024

based on the National Education Policy 2020

Theory: Semester 1

Course code	Unit	Topic Headings	Credits	Total number of hours
Mandatory 1 Virology and Cell Biology-I	1	Bacteriophages	4	15
	2	Plant Viruses		15
	3	Plasma membrane, Mitochondria and Chloroplast		15
	4	Endomembrane system		15
Mandatory 2 Genetics-I	1	Bacterial Cell Division, Chromosome partitioning and Gene expression	4	15
	2	Recombination, Mutation and Genetic Complementation		15
	3	Regulation of gene expression in bacteria		15
	4	Eukaryotes gene expression – Regulation and epigenetic modifications		15
Elective Microbial Biochemistry	1	Bioorganic molecules	2	15
	2	Analytical Biochemistry		15
Research Methodology	1	Basics of Research		15
	2	Sampling, data collection, interpretation and report writing		15
	3	Scientific writing and ethics in research and publication		15
	4	Biostatistics		15

Practicals: Semester 1

Course code	Title	Credits
Mandatory 1	Virology and Cell Biology-I	2
Mandatory 2	Genetics-I	2
Elective	Microbial Biochemistry	2

Semester 1

Mandatory 1- Virology and Cell Biology-I

Learning Objectives

To enable learners to

- gain an understanding of the replication and regulation of transcription of bacteriophages.
- understand the life cycle and other details of plant viruses and agents that infect plants such as Viroids.
- study cell biology of eukaryotic microorganisms and higher eukaryotes.
- 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, learners will be able to

- explain replication and regulation of gene expression of various bacteriophages.
- recall the structure, replication and life cycle of specific plant viruses and prevention and control of plant viral infections.
- describe the role of membrane proteins and transport, mitochondrial ETC, ATP synthesis and chloroplast in eukaryotes.
- summarize eukaryotic nuclear pore complex, Endoplasmic reticulum, Golgi complex and vesicle transport.
- elaborate vacuoles of eukaryotic microorganisms such as 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 in semester 2.

COURSE CODE	UNIT	TITLE Virology and Cell Biology-I	Number of hours

	I	**Bacteriophages**	**15**
		1.1 *E.coli* Phage T7: Genetic organization, regulation of transcription, DNA replication and maturation	
		1.2 a. *E.coli* Phage φX174: Replication, transcription, packaging b. Filamentous DNA phages- M13: Attachment and entry, replication, assembly and release	
		1.3 Single stranded RNA phages MS-2 and Qβ: Genetic organization and life cycle	
		1.4 a**.** Lambda phage: lytic and lysogenic cycle b. Bacteriophage Mu: Properties, Genetic organization and replication	
	II	**Plant Viruses**	**15**
		2.1 Viruses causing plant diseases: history, structure, transmission, symptoms, detection, prevention and control	
		2.2 Life cycles- overview Tobacco Mosaic Virus and Brome Mosaic Virus- Life cycle, host range, transmission, symptoms, diagnosis and control	
		2.3 Antiviral plant defense mechanisms: physical factors and RNA interference	
		2.4 Plant satellites and Viroids	
	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 a. Chemical composition of membranes- (in brief) - Membrane lipids (phosphoglycerides, sphingolipids, cholesterol), carbohydrates b. Structure and functions of membrane proteins - Integral membrane proteins, peripheral membrane proteins, lipid anchored membrane proteins c. Movement of substances across cell membranes - Diffusion of substances through membranes (Voltage-gated channels, Ligand-gated channels, Mechano-gated channels), Facilitated diffusion, Active transport	
		3.2 Mitochondria a. Mitochondrial structure and function- membrane and matrix b. Oxidative metabolism in the mitochondrion	

		c. Role of mitochondria in the formation of ATP - Electron transport, types of electron carriers, Establishment of proton motive force d. Machinery for ATP formation - Structure of ATP synthase, basis of ATP formation, Rotational catalysis	
		3.3 Chloroplast a. Chloroplast structure and function b. Photosynthetic metabolism c. Photosynthetic pigments, Photosynthetic units and reaction centers - PSII operations, PSI operations, and Photophosphorylation	
	IV	**Endomembrane system**	**15**
		4.1 Nuclear envelope, Structure of the Nuclear Pore Complex and its role in Nucleocytoplasmic exchange **4.2** The endoplasmic reticulum, The smooth endoplasmic reticulum , Functions of the rough endoplasmic reticulum- synthesis and processing of proteins **4.3** The Golgi complex, Types of vesicle transport and their functions- Cop II- coated vesicles, Cop I-coated vesicles and Endocytic pathway **4.4** Lysosomes, Contractile Vacuoles in algae and amoeba **4.5** Exosomes	

Mandatory 2 - Genetics-I

Learning objectives

To enable learners to

- gain an understanding of coordination of DNA replication, septum formation and chromosome partitioning in bacteria.
- understand molecular details of gene expression and its regulation in bacteria and eukaryotes.
- know recombination at the molecular level in bacteria and eukaryotic microorganisms such as yeast.
- understand the complementation test and its significance in mapping of genes.
- understand the lac operon and develop critical thinking skills
- gain knowledge of epigenetic modifications of genes in eukaryotes.

Learning outcomes

At the end of the course, learners be able to

- describe the role of bacterial proteins in septum formation and segregation of chromosomes and also in partitioning of plasmids.
- recall molecular details of transcription, RNA processing, splicing and translation.
- elaborate on the DSB repair model of recombination, role of proteins in bacterial and eukaryotic recombination and mating type switching in *Saccharomyces cerevisiae.*
- describe complementation test and fine structure mapping and their significance.
- distinguish between different mechanisms of regulation of bacterial operons
- compare different mechanisms of eukaryotic gene regulation.

COURSE CODE	UNIT	TITLE Genetics-I	Number of hours
	I	**Bacterial Cell Division, Chromosome partitioning and Gene expression**	**15**
		1.1 Cell division and chromosome partitioning in bacteria a. Replication and cell cycle b. Septum formation in bacteria, Function of FtsZ, MinCD and MinE c. Partitioning of Chromosomes d. Partitioning of single copy plasmids	

		1.2 Gene expression- Transcription - a. Bacterial Transcription b. Eukaryotic Transcription	
		1.3 RNA molecules and processing - a. Messenger RNA- Structure, processing, addition of the 5' Cap, addition of the Poly (A) tail, RNA splicing, self splicing introns, Alternative processing pathways, RNA editing b. Transfer RNA- Structure of transfer RNA, tRNA gene structure and processing c. Ribosomal RNA- Structure of the ribosome, rRNA gene structure and processing	
		1.4 Gene expression - Translation a. The process of translation- The binding of amino acids to transfer RNAs b. Initiation, elongation and termination of translation c. Posttranslational modifications of proteins	
	II	**Recombination, Mutation and Genetic Complementation**	**15**
		2.1 Recombination a. DSB repair model - steps b. Proteins involved in Homologous recombination in prokaryotes - RecBCD, RecA, RuvA, RuvB and RuvC c. Homologous recombination in eukaryotes and proteins involved in the same *d.* Mating type switching in *Saccharomyces cerevisiae* (Gene conversion) e. Concept of linkage	
		2.2 Mutation a. Somatic mutation and germline mutation b. Study of mutants	
		2.3 Genetic Complementation - Complementation test and fine structure mapping	

	III	**Regulation of gene expression in bacteria**	**15**
		3.1 Operons a. The *lac* operon of *E. coli* - Experimental evidence for the regulation of *lac* genes, mutations in the protein-coding and regulatory genes, and positive control of the *lac* operon b. The *ara* operon of *E. coli*: Positive and negative control c. The *trp* operon of *E. coli*- Attenuation **3.2 Other regulatory mechanism -** Antisense RNA, Riboswitches, Sigma factor switching- Sporulation in *Bacillus subtilis*	
	IV	**Eukaryotes gene expression – Regulation and epigenetic modifications**	**15**
		4.1 **Gene regulation in Eukaryotes-** **a.** Changes in chromatin structure and histone modifications **b.** Regulation of transcription factors and activators **c.** RNA Processing- Examples- SV40, sex differentiation in Drosophila, Degradation of RNA, RNA interference (in brief) **d.** Processes that affect translation and modification of proteins. **4.2 Epigenetic modifications that alter gene expression** a. Dosage compensation of genes on X chromosomes- mechanism of X chromosome inactivation b. Gene Imprinting – Mechanisms and imprinting disorders c. Noncoding RNAs d. DNA Methylation	

Elective : Microbial Biochemistry

Learning Objectives

To enable learners to

- To understand the structure and functions of important macromolecules.
- understand different analytical methods for studying macromolecules

Learning Outcomes

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

- describe the correlation between structure and functions of cellular macromolecules like proteins, lipids, carbohydrates.
- carry out extraction , purification and study of proteins
- elaborate on protein folding mechanism in cells
- apply appropriate techniques to characterize proteins
- outline use of radioisotopes in biology experiments

COURSE CODE	UNIT	TITLE Microbial Biochemistry	Number of hours 2 per week
	I	**Bioorganic molecules**	
		1.1 Structure and function of Proteins: Peptide bond and its stability, Ramachandran plot. Factors determining primary, secondary, tertiary and quaternary structure of proteins, thermodynamics of folding, role of disulfide bonds, dynamics of globular protein folding, chaperonins. Motifs and domains, protein families, protein stability, protein-protein interactions.	
		1.2 Glycobiology: Types of carbohydrates, glycosidic bond and its stability, Structure and functions of glycoconjugates, proteoglycans, glycoproteins, glycolipids and homopolysaccharides.	
		1.3 Lipids: Classification of lipids, structure and functions of glycerolipids, ether lipids, galactolipids, sulfolipids, lipids in archaebacteria, sphingolipids, terpenes, isoprenoids.	

	II	**Analytical Biochemistry**	
		1.1 General methods of purification of proteins: Use of salting out / salting in, organic solvents, column chromatography, electrophoresis.	
		1.2 Spectroscopic methods: Principle, Instrumentation and applications of Raman spectroscopy, IR spectroscopy, FTIR, Circular dichroism, NMR, ESR, X ray diffraction and mass spectroscopy	
		1.3 Radiolabeling techniques: Different types of radioisotopes, their detection, measurement and clinical applications.	

Learning Objectives

- To learn about the process of research, types of research and research design.
- To learn about different types of sampling methods, sampling designs and variables.
- To learn about methods of data collection, interpretation and report writing.
- To learn about scientific writing and ethics in research and publication.
- To use ICT as a tool to assist in writing research proposals and research outcomes.
- To learn about the use of biostatistics software in interpretation of data.

Learning Outcomes

At the end of the course, learner will be able to:

- Design a research proposal.
- Use appropriate methods of sample collection, methods of carrying out the research and write a report on the same.
- Use anti plagiarism software to check if the proposal is acceptable, prepare a manuscript
- To present research in a written / oral format using ICT.
- Learn use of biostatistics software so that it can be applied to the data collected for validity and interpretation.

COURSE CODE	UNIT	TITLE Research Methodology	Number of Lectures
	I	**Basics of Research**	**15**
		1.1 Meaning and objectives of research, research and scientific method, research process, research methods vs methodology. Criteria of good research, Problems encountered by researchers in India.	
		1.2 Types of research, conceptual vs empirical, applied vs fundamental, descriptive vs analytical, qualitative vs quantitative.	
		1.3 Research designs: Features of a good research design, different research designs. Case study, cross over study, case control design, cohort study design, multifactorial design, ex post facto	
	II	**Sampling, data collection, interpretation and report writing.**	**15**
		2.1 Sampling and sampling design: Steps and different types of sample design. Methods of sampling: non probability, simple random, systematic, stratified, quota, cluster and area sampling, multistage and sequential sampling. Problems due to unintended sampling,	

		ecological and statistical population in the laboratory. Variables: Nominal, ordinal, discontinuous and continuous.	
		2.2 Collection of data: Methods and techniques of data collection. Types of data collection: Primary and Secondary. Methods of primary data collection: Observation, Experimentation, Questionnaire, Interview, Schedules, Case pilot study etc. Methods of secondary data collection- Internal and External.	
		2.3 Interpretation and report writing: Techniques of interpretation and different steps involved in report writing, types of report, mechanics of writing a research report.	
	III	**Scientific writing and Ethics in research and publication**	**15**
		3.1 Abstract, Writing of Literature review, Aim and Objectives Methodology, References/ Bibliography and Preparation of manuscript for publication of research/ review paper. Peer reviewed, UGC CARE listed, indexed journals, citation index and role of citation, impact factor of a journal. Use of open sources such as Mendeley reference manager, LaTeX as writing software, storage using Google drive/ Dropbox. Science journalism.	
		3.2 Use of computer in research: Computer technology, computer and researchers, software tools in the structure, design and preparation of thesis, layout, labeling of figures, legends, preparation of tables, layout, etc. Preparation of oral presentation and posters.	
		3.3 Ethics in research and publication: Citations, acknowledgement, conflict of interest, plagiarism, plagiarism checking tools. Overview of ethics in research: Overview of legislation and regulation, ethical guidelines in animal and clinical research. IPR and patent law.	
	IV	**Biostatistics**	**15**
		4.1 Basics of Biostatistics: Measure of central tendencies, mean, mode, median. Measure of dispersion, Standard deviation, Standard error	

		of means, P value concept. Use of appropriate software for computation of statistical data.	
		4.2 Types of hypothesis: Basics concepts, types of hypothesis - Null and Alternate hypothesis, levels of hypothesis and testing of hypothesis. Parametric test: Z test, t test (1 tailed and 2 tailed test) of hypothesis. Different types of ANOVA test Non parametric test	
		4.3 Correlation analysis & Regression analysis: interpolation and extrapolation, nonlinear data fitting, probit analysis etc. Software used for all of the above.	
		Student activity: A hands on workshop will be organized to help students learn about the various biostatistics softwares. A talk will be organized to inform students on how to go about writing scientific articles to promote science journalism as a career choice.	

Practicals- Semester 1

Mandatory 1

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 a bacteriophage.
3	Study of lysogeny in *E. coli.*
4	Assignment on any plant virus (other than TMV and BMV).
5	Study of cell membrane integrity using uptake of neutral red.
6	Isolation of mitochondria
7	Isolation of chloroplasts.

Mandatory 2

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
6	β- galactosidase assay
7	Problems on *lac* operon

Elective

Microbial Biochemistry

Sr. No	Name of the
1	Extraction of total lipids.
2	Isolation of cholesterol and lecithin from egg yolk.
3	Identification of fatty acids and other lipids by TLC.
4	Determination of degree of unsaturation of fats and oils.
5	Isolation of lactose from bovine milk.
6	Estimation of total sugars by phenol-sulphuric acid method.
7	Isolation of glutamic acid from gluten.
8	Isolation, Purification of Beta amylase from fungi using salting out and dialysis
9	Estimation of beta amylase activity using the DNSA method.

10	Estimation of protein content of beta amylase and calculation of specific activity.
11	Estimation of polyphenols/ tannins by Folin-Denis method
12	Visit to an Instrumentation facility

References – Semester 1

Mandatory Paper 1

1. **Freifelder, David**.(2004). Molecular Biology, 2nd edition. Narosa Publishing House.
2. **Willey, Joanne M., Sherwood Linda M., Woolverton Christopher J.** (2014) Prescott's Microbiology, 9th edition, McGraw-Hill Higher Education.
3. **Madigan, Michael., Martinko, John., Bender, David., Buckley, Daniel., and Stahl, David** (2015). Brock Biology of Microorganisms, 14th edition. Pearson.
4. **Shors, Teri**. (2009). Understanding viruses, 1st edition. Jones and Bartlett Publishers.
5. **Shors, Teri** (2016) Understanding viruses, 3rd edition, Jones and Bartlett Publishers.
6. **Knipe, David, M., and Howley, Peter.M.** (2001). Fields Virology 4th edition, Lippincott Williams and Wilkins
7. **Mahy, Brian WJ., and Regenmortel, Marc HV Van**. (2010). Desk Encyclopedia of General Virology. Elsevier.
8. **Cann, Alan**. (2015). Principles of Molecular Virology, 6th edition. Academic Press.
9. **Karp, Gerald**. (2010). Cell and Molecular Biology, 6th edition. John Wiley & Sons, Inc.
10. **Becker, William M., Kleinsmith, Lewis J., & Hardin, Jeff**. (2019). Becker World of Biology, 11th edition Pearson.
11. **Lodish, Harvey., Berk, Arnold., and Kaiser, Chris A.** (2007). Molecular Cell Biology, 6th edition. W.H. Freeman & Co Ltd.

Mandatory Paper 2

1. **Lewin, Benjamin**. (2004). Genes VIII. Pearson.
2. **Lewin, Benjamin**. (2007). Genes IX., Jones and Bartlett publishers.
3. **Pierce, Bruce A**. (2003). Genetics- A Conceptual approach, Worth Publishers Inc., US.
4. **Pierce, Bruce A.** (2013). Genetics- A Conceptual approach, W.H. Freeman
5. **Watson, James D., Baker, Tania A., Bell, Stephen P., Gann A., Levine, M., Losick., R**. (2003). Molecular Biology of the Gene, 5th edition. Cold Spring Harbor Laboratory Press.
6. **Watson, James D., Baker, Tania A., Bell, Stephen P., Gann A., Levine, M., Losick., R. (**2013). Molecular Biology of the Gene, 7th edition. Pearson.
7. **Stanier, Roger Y., Adelberg, Edward A., and Ingraham, John L.** (1976). General Microbiology, 4th edition. Macmillan.
8. **Russell, Peter J**. (2010). iGenetics: A Molecular Approach, 3rd edition. Pearson.
9. **Tamarin, Robert H.** (2002). Principles of Genetics, 7th edition. McGraw-Hill.
10. **Weaver, Robert F**. (2012). Molecular Biology, 5th edition. McGraw-Hill.
11. **Watson, James D., Caudy Amy A., Myers, Richard M., and Witkowski Jan A. (**2007) Recombinant DNA, Genes and Genomics - A short course, 3rd Edition. W.H. Freeman and Company.
12. **Brooker, Robert**. (2017). Genetics: Analysis and Principles, 6th edition. McGraw-Hill Higher Education.

Elective

1. Lehninger Principles of Biochemistry Nelson, D., and Cox, (4th Ed.), 2005 M.; W.H.Freeman and Company, New York.
2. Biochemical calculations, Segel I.R., 2nd edition, 2004, John Wiley and Sons.
3. Essential Biochemistry (illustrated) Pratt-Cornley 3rd edition 2013, Wiley.
4. The physiology and biochemistry of prokaryotes, White D., 4th edition, 2011, Oxford University Press
5. Exploring proteins: Student's guide to experimental skills and methods, N. Price J. Naira,2009 Oxford University Press
6. Outlines of Biochemistry by Conn and Stumpf 5th edition 2006 Wiley India Edition.

References for practicals

7. Lab Manual in biochemistry – Jayaraman, New Age International Publishers
8. Principles and techniques of practical biochemistry, 4th PP edition, Wilson K. and Walker J. (Ed.) Cambridge University Press, 1994
9. Experimental biochemistry –A student companion, Rao Beedu, S. Deshpande, IK international Pvt. Ltd.

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 allosteric regulations: -Regulation by covalent modification, -Regulation by multienzyme complexes and multifunctional enzymes (the blood coagulation cascade)	3
		2.6 Study of Enzyme action using X-ray crystallography,	2

		Bioorganic Mechanism of enzyme catalyzed reactions: Stereochemical aspect of inhibition by penicillin	
	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**

SMSMCB301:

Learning Objectives ● To learn about the process of research, types of research and research design. ● To learn about different types of sampling methods, sampling designs and variables. To learn about methods of data collection, interpretation and report writing. ● To learn about scientific writing and ethics in research and publication. To use ICT as a tool to assist in writing research proposals and research outcomes. ● To learn about the use of biostatistics software in interpretation of data.

:Learning Outcomes At the end of the course, learner will be able to: ● Design a research proposal. ● Use appropriate learn methods of sample collection, methods of carrying out the research and write a report on the same. ● Use anti plagiarism software to check if the proposal is acceptable, prepare a manuscript for presentation in a written / oral format using ICT. ●Learn use of biostatistics software so that it can be applied to the data collected for validity and interpretation.

Unit I Basics of Research

1.1 Meaning and objectives of research, research and scientific method, research process, research methods vs methodology. Criteria of good research, Problems encountered by researchers in India.

1.2 Types of research, conceptual vs empirical, applied vs 4 fundamental, descriptive vs analytical, qualitative vs quantitative.

1.3 Research designs: Features of a good research design, different research designs. Case study, cross over study, case control design, cohort study design, multifactorial design, ex post facto.

Unit II Sampling, data collection, interpretation and report writing.

2.1 Sampling and sampling design: Steps and different types of sample design. Methods of sampling: non probability, simple random, systematic, stratified, quota, cluster and area sampling, multistage and sequential sampling. Problems due to unintended sampling, ecological and statistical population in the laboratory. Variables: Nominal, ordinal, discontinuous and continuous.

2.2 Collection of data: Methods and techniques of data collection. Types of data collection: Primary and Secondary. Methods of primary data collection: Observation, Experimentation, Questionnaire, Interview, Schedules, Case pilot study etc. Methods of secondary data collection- Internal and External.

2.3 Interpretation and report writing: Techniques of interpretation and different steps involved in report writing, types of report, mechanics of writing a research report.

Unit III Scientific writing and Ethics in research and publication

3.1 Abstract, Writing of Literature review, Aim and Objectives Methodology, References/ Bibliography and Preparation of manuscript for publication of research/ review paper. Peer reviewed, UGC CARE listed, indexed journals, citation index and role of citation,

impact factor of a journal. Use of open sources such as Mendeley reference manager, LaTeX as writing software, storage using Google drive/ Dropbox. Science journalism.

3.2 Use of computer in research: Computer technology, computer and researchers, software tools in the structure, design and preparation of thesis, layout, labeling of figures, legends, preparation of tables, layout, etc. Preparation of oral presentation and posters.

3.3 Ethics in research and publication: Citations, acknowledgement, conflict of interest, plagiarism, plagiarism checking tools. Overview of ethics in research: Overview of legislation and regulation, ethical guidelines in animal and clinical research. IPR and patent law.

Unit IV Biostatistics

4.1 Basics of Biostatistics: Measure of central tendencies, mean, mode, median. Measure of dispersion, Standard deviation, Standard error of means, P value concept. Use of appropriate software for computation of statistical data.

4.2 Types of hypothesis: Basics concepts, types of hypothesis - Null and Alternate hypothesis, levels of hypothesis and testing of hypothesis. Parametric test: Z test, t test (1 tailed and 2 tailed test) of hypothesis. Different types of ANOVA test Non parametric test.

4.3 Correlation analysis & Regression analysis: interpolation and extrapolation, nonlinear data fitting, probit analysis etc. Software used for all of the above.

Student activity: A hands on workshop will be organized to help students learn about the various biostatistics softwares.

A talk will be organized to inform students on how to go about writing scientific articles to promote science journalism as a career choice.