



SOPHIA COLLEGE
(AUTONOMOUS)

Affiliated to the University of Mumbai

Syllabus for Semesters I to II

Program: M.Sc.

Course: Life Sciences

(Choice Based Credit System with effect from the year 2021-2022)

PREAMBLE

The syllabus for the first year of M.Sc has been designed to understand the major biological processes and interactions of molecules at the cellular level. This information would nurture their ability to relate molecular and functional features to cellular as well as at the tissue level organization.

This course would also enable the students enhance their ability to think logically, analyze the information and help in problem solving skills in biology. The course encourages use of computer softwares.

The section on research methodology would help in designing experiments after forming appropriate hypotheses, in data collection as well as their ability to analyze, interpret and conclude their research findings. This would enable them to communicate scientific ideas effectively.

M.Sc. Part I Life Sciences Syllabus

Choice based Credit and Grading System

Academic year 2021 -22

SEMESTER I

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	LECTURES
Paper I	Macromolecules			
SMSLSC101	1	Cell biochemistry	4	15
	2	Nucleic acid biochemistry		15
	3	Protein biochemistry		15
	4	Techniques in macromolecular biology		15
SMSLSCP101	Practical		2	
Paper II	Cell Biology I			
SMSLSC102	1	Biology of Prokaryotes	4	15
	2	Biology of Eukaryotes - I		15
	3	Biology of Eukaryotes - II		15
	4	Techniques in cell biology I		15
SMSLSCP102	Practical		2	
Paper III	Systems Biology I			
SMSLSC103	1	Physiology I- Digestive, Circulatory and Excretory Systems	4	15
	2	Immunology		15
	3	Infectious animal and plant diseases		15
	4	Techniques in Systems Biology I		15
SMSLSCP103	Practical		2	
Paper IV	Bioethics, Toxicology, Biostatistics I and Research methodology			
SMSLSC104	1	Bioethics	4	15
	2	Toxicology		15
	3	Biostatistics I		15
	4	Research Methodology		15
SMSLSCP104	Practical		2	

SEMESTER II

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	LECTURES
Paper I	Principles of Genetics			
SMSLSC201	1	Inheritance biology	4	15
	2	Regulation of gene expression, Epigenetics and DNA damage & repair		15
	3	Molecular Biology/Genetics		15
	4	Techniques in genetics		15
SMSLSCP201	Practical		2	
Paper II	Cell Biology II			
SMSLSC202	1	Cell cycle and its regulation	4	15
	2	Cell death and cell survival		15
	3	Cell signalling		15
	4	Techniques in cell biology II		15
SMSLSCP202	Practical		2	
Paper III	Systems Biology II			
SMSLSC203	1	Physiology II- Endocrinology, Reproductive biology and nervous system	4	15
	2	Physiology III- Developmental Biology		15
	3	Plant Physiology and plant defense		15
	4	Techniques in systems biology II		15
SMSLSCP203	Practical		2	
Paper IV	Evolution, Population Biology, Biostatistics II and Bioinformatics			
SMSLSC204	1	Evolution	4	15
	2	Population biology		15
	3	Biostatistics II		15
	4	Bioinformatics		15
SMSLSCP204	Practical		2	

SEMESTER I

COURSE CODE: SMSLSC101 PAPER –I MACROMOLECULES

Course objective

CO1: To learn fundamentals of thermodynamics.

CO2: To have an understanding of behaviour of molecules in context to thermodynamics.

CO3: To acquire a clear understanding of processes involving Nucleic acid biochemistry.

CO4: To understand details of protein structure and folding, and its relation to protein function.

CO5: To introduce the students to different techniques in macromolecular biology.

Learning Outcome:

The students will be able to

LO1: Relate the fundamentals of thermodynamics and molecular biology behaviour in the biochemical reaction.

LO2: Have a clear understanding of the important molecular biology process of Gene transcription and regulation.

LO3: Have a clear understanding of protein biochemistry at molecular level.

LO4: Understand the principle behind techniques involved in Macromolecular biology.

Total: 45 lectures

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC101	1	Cell biochemistry	1	15
		1. The concept of Energy and Work within cells – The laws of thermodynamics, Enthalpy, Entropy and Free energy concept and their relevance to biological systems.		1
		2. Energy coupling in mechanical and chemical processes during a chemical reaction.		1
		3. Importance of pH in biology, biological inorganic buffers; Amino acids and Proteins as buffers		2
4. Metabolism of biomolecules: Synthesis and breakdown of carbohydrates, lipids, amino acids, nucleotides and vitamins (lipid soluble and insoluble) using one typical example each	11			
SMSLSC101	2	Nucleic acid biochemistry	1	15
		1. Nucleic acid		3
		a) DNA: Components, Structure and function of the molecule; Conformation of nucleic acids (A, B and Z-DNA), b) RNA: Types, Structure and function, coding and non-coding RNA		
2. Nucleic acid packing: Packing of DNA into chromosomes – structure-function relationships; chromatin organization and remodeling, Proteins associated with chromosome structure (scaffold and associated proteins)	2			
3. Prokaryotic DNA: Bacterial Circular	1			

		<p>chromosomes and extra-chromosomal DNA- Plasmids, Viroids</p> <p>4. DNA Replication</p> <p>a) Mechanisms of DNA replication in prokaryotes and eukaryotes: DNA modifying enzymes (kinases, polymerases, ligases).</p> <p>b) DNA replication models, connection of replication to cell cycle,</p> <p>c) Reverse Transcriptase and Restriction endonucleases</p> <p>5. Transcription</p> <p>a) in prokaryotes (<i>Lac</i> and <i>trp</i> operon)</p> <p>b) in eukaryotes: initiation, elongation and termination</p> <p>c) Post-transcriptional processing and transport of RNA, Non-coding RNAs</p>		4
				5
SMSLSC101	3	<p>Protein biochemistry</p> <p>1. Amino acids, Peptides– Biochemical nature of Amino acids, Bonds and interactions in peptides, Domains and Motifs in peptides</p> <p>2. Protein- Conformation of proteins, Structure-function relationships of typical proteins – fibrous and globular, Ramachandran plot</p> <p>3. Enzymes – Classification, Activity and Specific activity, Enzyme kinetics, Enzyme inhibition, Allosteric enzymes, Application of Enzymes in Industry, Agriculture and Research</p> <p>4. Translation: structure of ribosome; mechanism of translation- initiation, elongation and termination</p> <p>5. Post translational Modifications</p> <p>a) Protein folding- Molten globule, chaperon, Protein Misfolding</p> <p>b) Protein Processing- Proteolytic cleavage (Pre, Pro, removal)</p> <p>c) Protein Modifications – Glycosylation, Phosphorylation</p> <p>d) Protein trafficking (anterograde and retrograde)</p> <p>6. Protein degradation – proteosomal and lysosomal</p>	1	15 2 2 3 3 4 1
SMSLSC101	4	<p>Techniques in macromolecular biology</p> <p>1. PCR, Nested PCR, Multiplex PCR, RT-PCR, qRT- PCR, RAPD, RFLP, DNA sequencing.</p>	1	15 5

		2. Protein purification: a) Centrifugation b) Sedimentation c) Chromatography (Adsorption, Affinity, Gel filtration, ion-exchange, HPLC)		3 1
		3. Protein sequencing/detection of amino acids: Edman's and Sanger's reaction		1
		4. Spectrophotometry in quantitation of macromolecules.		5
		5. X-ray crystallography		

Reference Books:

- Berg J.M., Tymoczko J.L., and Stryer L., Biochemistry, 2006, 6th edition, *Freeman Publishers, New York.*
- Brooker, Robert J., Concepts of Genetic, 2012, 2nd Edition, *McGraw-Hill Publication.*
- Hardin J., Bertoni J.P., Kleinsmith L.J., Becker's World of the Cell: International Edition, 2011, 8th Edition, *Pearson Publishers.*
- Nelson D.L. and Cox M.M., Lehninger Principles of Biochemistry, 2000, 6th edition. *Worth Publishers, New York.*
- Lewin, B., Genes XI, 2006, 11th Edition, *Jones and Bartlett Publishers.*
- Pierce B., Genetics: A Conceptual Approach, 3rd edition, 2008, *W. H. Freeman & Co.*
- Plummer M. and Plummer D.T., Introduction To Practical Biochemistry, 1988, 3rd Edition, *McGraw Hill Publication*
- Strachnan T. and Read A.P. Human Molecular Genetics, 2014, 4th Edition, *Garland Science Publisher.*
- Russell, P.J., iGenetics- A Molecular Approach, 3rd edition, 2010, *Pearson Publishers.*
- Snustad & Simmons, Principles of Genetics, 6th edition, 2012, *John Wiley & Sons Inc.*
- Voet D. and Voet J.G., Biochemistry, 2010, 4th edition, *Wiley & Sons Publishers, New York.*
- Wilson, K. & Walker, J., Principles and Techniques of Biochemistry and Molecular Biology, 2010, 7th Edition, *Cambridge University Press.*

SEMESTER I

COURSE CODE: SMSLSC102

PAPER –II CELL BIOLOGY I

Course Objectives:

CO1: To enable understanding of microbial diversity and structure of prokaryotic cell

CO2: To understand microbial growth and its control

CO3: To introduce students to Organelles of eukaryotic cells – structure and function

CO4: To understand concept of intercellular communication and various methods used to study cellular processes

Learning Outcome

The Students will be able to

LO1: Distinguish between different forms of bacteria and archaea .

LO2: Have thorough knowledge of characteristics of antibiotic drugs and the mode of action

LO3: Have understanding of Eukaryotic cell, the membrane, the organelles and the benefits of compartmentalization

LO4: Further understand the function of cytoskeleton and the importance of cell junctions

Total: 45 lectures

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC102	1	Biology of Prokaryotes	1	15
		1. Viruses: Structure and life cycle of bacteriophage, DNA virus and RNA virus.		3
		2. Microbial diversity:		3
		a) Bacteria: characteristics and any 3 types with examples (Purple and green bacteria, budding bacteria rods, Spirochetes, Sheathed bacteria, Endospore forming rods and cocci)		
		b) Archaea: Archaea as earliest life forms; General characteristic and types (Halophiles, Methanogens; Hyperthermophilic archaea and Thermoplasma)		
3. Prokaryotic Cell Structure- overview	3			
4. Microbial Growth: Growth curve	3			
5. Chemotherapy/Antibiotics: General characteristics of antimicrobial drugs; Antibiotics: Classification, mode of action and resistance; Antifungal and antiviral drugs.	3			
SMSLSC102	2	Biology of Eukaryotes – I	1	15
		1. Plasma Membrane Structure, lipid bilayer, membrane proteins		2
		2. Principles of Membrane Transport: Transporters and Active Membrane Transport; Ion Channels and electrical properties of membranes		3
3. Intracellular Compartments and Protein Sorting: Compartmentalization of cells, Endoplasmic Reticulum, Golgi apparatus and transport from ER to Golgi and lysosomes,	6			

		Endocytosis and Exocytosis; Transport of molecules into nucleus, mitochondria, chloroplast and peroxisomes. Proteosomal destruction of aberrant proteins 4. Nucleus: Membrane and nuclear pore complex, nucleolus, nucleosome model		4
SMSLSC102	3	Biology of Eukaryotes – II 1. Energy conversion: Mitochondrion and electron transport chain, Chloroplast and photosynthesis. 2. Cytoskeleton: Dynamic structure of Cytoskeletal filaments, Molecular motors, functions of cytoskeleton 3. Cell junctions, Cell adhesion and Extracellular Matrix: Tight junctions, Gap Junctions, Adhesion junctions, Cadherins, Integrins 4. Extracellular matrix	1	15 5 4 4 1 1
SMSLSC102	4	Techniques in cell biology I 1. Visualizing cells: Microscopy-Light microscopy, Phase contrast and DIC for unstained cells, Fluorescence microscopy, Confocal microscopy, Electron microscopy 2. Techniques to enhance visualization: Fluorescent tags for live imaging, antibody or radioisotope binding for specific molecule detection, light emitting indicators for ion concentrations, Optical traps to manipulate objects, single molecule visualization using Total Internal Reflection Fluorescence microscopy. 3. <i>in situ</i> localization and FISH	1	15 5 7 3

Reference Books:

- Alberts B. et al, Molecular Biology of the Cell, 2016, *Garland Science*
- Hunt T and Wilson J., The Problem Book - for Molecular Biology of the Cell?
- Karp G., Iwasa J., Marshall W., Cell Biology, 8th Edition, 2013, *Wiley International Publisher.*
- Lodish H., Molecular Cell Biology, 5th Edition, 2016, *W. H. Freeman & Co.*
- Brock, Biology of Microorganisms, 13th Edition, 2012, *Benjamin Cummins*
- Spector, David L. & Goldman, R.D., Basic Methods in Microscopy: Protocols and Concepts From Cells: A Laboratory Manual, 2006, *Cold Spring Harbour Laboratory Press.*
- Tortora G., Microbiology an Introduction, 10th Edition, 2010, *Benjamin Cummins*
- Willey J., Prescott's Microbiology, 10th Edition, 2017, *McGraw Hill Education*

SEMESTER I

COURSE CODE: SMSLSC103

PAPER –III SYSTEMS BIOLOGY I

Course Objectives

CO1: Familiarize the students to Physiological systems

CO2: Introduce the students to the basics of Immunology

CO3: Describe the significance of Host Parasite interactions and diseases

CO4: Illustrate and demonstrate the techniques used in physiology and immunology

Learning Outcomes

The students will be able to

LO1: Comprehend the mechanism of Physiological systems that maintain homeostasis-Digestive, Circulatory, Excretory

LO2: gain an understanding regarding the immune cells, organs of the immune system and immune response

LO3: understand the details about host parasite interactions and apply the knowledge while performing experiments

LO4: compare, contrast and also apply the techniques used in physiology and immunology during their project work

Total: 45 lectures

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC103	1	Physiology-I	1	15
		<ul style="list-style-type: none"> • Levels of Organization of Animal body at Tissue and Organ level. • Concept and Definition of Homeostasis. Homeostatic control and their relevance. • Disruptions in Homeostasis and its impact on Physiology. 		3
		<p>I. Digestive system:</p> <ol style="list-style-type: none"> 1. Digestive tract and accessory digestive organs. 2. Digestive processes and an overview of three major nutrients. 3. Gastrointestinal Hormones 		4
		<p>II. Circulatory System:</p> <ol style="list-style-type: none"> 1. Blood, blood vessels and blood pressure. 2. Anatomy of the heart and its electrical activity. 3. Events associated with cardiac cycle. 		4
		<p>III. Excretory system:</p> <ol style="list-style-type: none"> 1. Nephron as a functional unit, 2. Basic renal processes, Globular filtration, Tubular reabsorption, and Tubular excretion. 3. Urine excretion and body's state of hydration. 		4
SMSLSC103	2	<p>Immunology</p> <ol style="list-style-type: none"> 1. Cells and organs of the Immune System, Mechanisms of Innate immunity – including Complement system 2. Antibody structure and function, Generation of antibody diversity, B cell ontogeny 3. T cell receptors and their diversity, T cell ontogeny – Helper and cytotoxic T cell 4. MHC molecules and antigen presentation 	1	15
				3
				4
				4
				2

		5. Vaccine- active and passive immunization; Types of vaccine		2
SMSLSC103	3	Diseases: I. Host parasite interactions and Diseases 1. Mechanisms of pathogenesis: bacterial and viral; Parasite evasion strategies 2 2. Study of following infections including Etiology, Transmission, Pathogenesis, Clinical Manifestations, Laboratory diagnosis, Prophylaxis, and Treatment 10 a. Bacterial- eg. Typhoid, Cholera, Tuberculosis / Leprosy b. Viral- eg. Polio, AIDS c. Parasitic- eg. Malaria, Roundworm/ Filariasis, Ebola/ Zika d. Fungal- eg. Candidiasis II Plant Pathology 1. Tungro virus 2. Bacterial Leaf Blight 3. Red rot disease 4. Root-knot nematode 5. Production of disease free plants 3	1	15
SMSLSC103	4	Techniques in systems biology I 1. Physiology I a) Kidney function tests – BUN, creatinine (range, basic interpretation/biological significance) b) Cardiac function tests – Troponin, creatinine kinase (range, basic interpretation/biological significance) 2. Techniques in immunology a) Immunoelectrophoresis b) ELISA, Western blot, Chemiluminescence c) Immunohistochemistry and Immunofluorescence, d) Production of Monoclonal antibodies	1	15 7 8

Reference Books:

- Alberts B., Johnson A., Lewis L., Morgan D., Raff M., Roberts K., Walter P., Molecular Biology of the Cell, 2007 or 2014, 5th Edition or 6th Edition, *Garland Science Publication*.
- Delves P., Mastin S. et al, Roitt's Essential Immunology, 2006, 11th Edition, *Blackwell Publishing*.
- Guyton A.C. and Hall J.E., Text Book of Medical, 2006, 11th Edition, *Elsevier Saunders*
- Kuby Immunology by Punt, Stranford, Jones, Owen, 2018, 8th ed, *W. H. Freeman*.
- Mukherjee, Kanai L., Medical Laboratory Technology, 1988, Reprint Edition, *Tata MacGraw Hill Publishing Co. Ltd., New Delhi*.
- Seeley R, Stephens T and Tate P, Anatomy and Physiology, 2004, 6th Edition, *The McGraw–Hill Companies*.
- Spector, David L. & Goldman, R.D., Basic Methods in Microscopy: Protocols and Concepts From Cells: A Laboratory Manual, 2006, *Cold Spring Harbor Laboratory Press*.
- Taiz, Zeiger, Moller and Murphy, Plant Physiology, 2014 6th edition, *Sinauer Publications*.
- Taylor D.J., Green N.P.O., Stout G.W., Ed. Soper R., Biological Science, 2005, 3rd Edition, *Cambridge University Press*.
- Tortora G. and Grabowski S., Principles of Anatomy and Physiology, 2010, 10th Edition, *John Wiley & Sons, Inc*.

SEMESTER I

COURSE CODE: SMSLSC104

PAPER –IV BIOINFORMATICS, TOXICOLOGY, BIostatISTICS I AND RESEARCH METHODOLOGY

Course Objectives

CO1: Apprehend the major classes of toxicology, different toxins, and route of exposure, risk assessment, prediction and management.

CO2: Demonstration and understanding of the central concepts of modern statistical theory and their probabilistic foundation.

Learning outcomes

The Students will be able to

LO1: Design, execute and statistically analyse experiments using the principles of scientific research methodology.

LO2: Interpret results by using descriptive statistical methods effectively.

Total: 45 lectures

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC104	1	Bioinformatics	1	15
		1. Introduction to bioinformatics and History of bioinformatics		2
		Biological databases and their types –Primary and secondary databases, specialized databases, possible limitations of databases .		1
		3. Pairwise sequence alignment – Local and global alignment, Dot Plot/Dynamic Programming, PAM and BLOSUM, BLAST and its variants, FASTA, statistical significance (P and E value).		3
		4. Multiple Sequence alignment - Heuristic approach (progressive alignment, iterative alignment and block based alignment).		3
		5. Phylogenetic trees – Molecular evolution, rooted and unrooted trees, phylograms and cladograms, UPGMA, Neighbour Joining Method, Maximum Parsimony.		3
		6. Gene Prediction: Concept of six frame translation, Methods for gene prediction – homology and Ab initio		
7. Omics techniques: Genomics (SNP microarray), transcriptomics (cDNA microarray), Mass spectrometry-based proteomics (chemical versus metabolic labeling, gel based versus gel free methods) and omics data management (e.g. gene ontology)	3			

SMSLSC104	2	Toxicology <ol style="list-style-type: none"> 1. History of toxicology, classification of toxicology. 2. Toxicants: Exposure, exposure characterization. 3. Routes of exposure: Organism environment interaction, Animal and plant toxins, Absorption and distribution of toxicants, 4. Hazard identification: Risk assessment (Human health risk assessment) Risk prediction and Management (management of acute intoxication, natural detoxification– Biochemical and genetic mechanism) 	1	15 2 2 5 6
SMSLSC104	3	Biostatistics I <ol style="list-style-type: none"> 1. Data: types of data, collection & classification, Frequency distribution, diagrammatic & graphical representation of data 2. Measures of central tendency and measures of variation/dispersion 3. Probability: Types of Probability (Mathematical & Statistical), their characteristics and limitations, Theorems of Probability- Additional, Multiplication theorem, Permutation & Combination, Random Variable, Theoretical Probability Distribution, Baye's theorem 4. Normal Distribution (Z score), Binomial Distribution, Poisson Distribution 5. Correlation: Introduction, types of Correlation, method of study of correlation & application. 6. Regression: Types of regression, regression lines & its properties. 	1	15 2 3 3 3 2 2

SMSLSC104	4	Research Methodology:	1	15
		1. Introduction and rationale		1
		2. Types of Research studies: Prospective or Retrospective; Case-control, Cross-sectional, longitudinal (to be applied to students' actual research projects)		2
		3. Definition and Formulation of a Problem, Designing and conducting a research project		2
		4. Method of data collection: Experiments, Interviews, Questionnaires and Surveys, Data records of data storage and good laboratory practices		2
		5. Reporting: Principles of effective writing: Literature review, Report writing: Thesis/Dissertation, Grant writing		3
		6. Types of grants: Fellowship/ Travel/ Project/Conference/Workshop & Proposal writing		2
		7. Plagiarism in research		1

Reference Books

- Arora P.N. & Malhan P.K. Biostatistics, 2002, First Reprint Edition, *Himalaya Publishing House*.
- Banerjee P.K., Introduction to Biostatistics, 2004, First Edition, *S. Chand & Company Pvt. Ltd.*
- Booth V., Communicating in Science: Writing a Scientific Paper and Speaking at Scientific Meetings, 2003, *Cambridge University Press*.
- Creswell J.W., Creswell J.D., Research Design: Qualitative, Quantitative, and Mixed Method Approaches, 2017, *Sage Publications*.
- Day R. A., Gastel B., How to Write & Publish a Scientific Paper, 2011, *Greenwood*.
- Gurumani N., An Introduction to Biostatistics, 2011, Second Revised Edition, *M.J.P. Publisher*.
- Gurumani N., Research Methodology for Biological Sciences, 2006, *MJP Publishers*.
- Mahajan B.K., Methods in Biostatistics, 2002, Sixth Reprint Edition, *Jaypee Brothers Medical Publishers (P) Ltd.*
- Matthews J.R., Matthews R.W., Successful Scientific Writing: A Step-By-step Guide for the Biological and Medical Sciences, *Cambridge University Press*.
- Marczyk G., DeMatteo D., Festinger D., Essentials of Research Design and Methodology, 2010, *John Wiley and Sons, Inc.*
- Laake P., Benestad H.B., Olsen B.R., Research Methodology in the Medical and Biological Sciences, 2007, *Acad Press*.
- Santra S.C., Fundamentals of Ecology and Environmental Biology, 2010, First Edition, *New Central Book Agency (P) Ltd.*

SEMESTER I

PRACTICAL

COURSE CODE: SMSLSCP101

1. How to Write a Lab Report
2. Extraction of lipid by Bligh and Dyer method and detection and estimation by TLC
3. Extraction and estimation of ascorbic acid from vegetable source by colorimetric method
4. Extraction and estimation of phosphorous by Fiske-Subbarao method
5. Estimation of Amino acids by Ninhydrin method
6. Enzyme kinetics, effects of pH, temperature, time and substrate concentration, determination of Km and Vmax using potato phosphatase/Amylase/ Enzyme assay to measure the activity of succinate dehydrogenase.
7. Isolation of chloroplasts from spinach (or any other suitable system) and chlorophyll estimation.

COURSE CODE: SMSLSCP102

8. Staining of capsule/endospore/flagella from the given culture
9. Electron Micrographs of cell organelles (demonstration)
10. Preservation of micro-organisms: sub culturing, glycerol stocks, concept of lyophilization (demonstration).
11. Growth curve of *E. coli* and Diauxic growth curve.
12. Isolation of auxotrophic mutants after exposure to UV/ chemical mutagen.
13. Induction of the Lac operon and assessment of enzyme activity using a suitable system (e.g. *E. coli*).
14. Antibiotic sensitivity tests – Agar Cup method and Disc Diffusion method
15. Microscopy – light, phase contrast, DIC, fluorescence (nuclear staining using Ethidium bromide or DAPI / lysosomal staining using acridine orange / phalloidin staining for actin filaments) – Demonstration

COURSE CODE: SMSLSCP103

16. Histology – processing of tissue, preparation and cutting of sections and staining and preparation of permanent slide
17. Agglutination Reactions: Study of Blood groups, Isohemagglutinin titre in blood and Quantitative Widal Test
18. Precipitation Reactions: Single (Radial) immunodiffusion and Double immunodiffusion (Ouchterlony)
19. Separation of Mononuclear cells (lymphocytes) using a gradient and the determination of viable count of the same (Demonstration).
20. Innate Immunity: Testing the effects of saliva/tears/lysozyme on *Staphylococcus*, *Streptococcus*.
21. Biochemical tests for identification of microorganisms: Catalase, IMViC, Urease
22. Recording and Measurement of Blood Pressure, Correlation significance of Systole/Diastole and Heart rate, recording of ECG (Interpretation)

COURSE CODE: SMSLSCP104

23. Determination of population density (*Daphnia* or any suitable organism) by sub sampling method
24. Effect of toxicity in water on *Daphnia*.
25. Calculation of Biodiversity index from the given table-top habitat.
26. Extraction of DNA by DPA method using a suitable source, estimation of purity and visualization by Agarose gel electrophoresis.
27. Isolation of RNA from a suitable system and estimation (orcinol reagent), estimation of purity and visualization by Agarose gel electrophoresis.
28. Extraction and estimation of proteins by Folin Lowry
29. Separation of proteins using SDS-PAGE
30. Biostatistics:
 - a) Measures of central tendency and measures of variation/dispersion
 - b) Probability
 - c) Normal Distribution (Z score), Binomial Distribution, Poisson Distribution
 - d) Correlation
 - e) Regression
31. Bioinformatics:
 1. Multiple sequence alignment
 2. Phylogenetic tree analysis
 3. BLAST- BLASTn, BLASTp,
 4. Primer designing using BLAST and BioEdit
 5. Gene ontology
 6. OMIM
 7. KEGG
 8. Finding ORFs

Students are expected to have done the following experiments at the undergraduate level. However, if any student has not been exposed to them, they are expected to perform them prior to commencement of the PG practical.

1. Preparation of solutions and verification of Beer-lamberts law.
2. Estimation of sugar by DNSA method/ Starch by Anthrone method
3. Separation of amino acids by paper chromatography.
4. Mitosis in plant cells (onion root tips)
5. Study of nephridium, study of nephron histology study and analysis of a given urine sample.
6. Peripheral bloods smear preparation and staining.
7. Permanent slides of tissues.

SEMESTER II

COURSE CODE: SMSLSC201

PAPER –I PRINCIPLES OF GENETICS

Course Objectives

- CO1:** To understand the theory of classical genetics
- CO2:** To understand the DNA repair mechanism
- CO3:** To acquire detailed understanding of Regulation of gene expression.
- CO4:** Introduce techniques in genetics

Course Outcome:

Students will be able to

- LO1:** Explain the concept of Classical genetics.
- LO2:** Understand the processes involved in regulation of genes.
- LO3:** Understand different tools in genetics and to apply these techniques for genetic manipulation.

Total: 45 lectures

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC201	1	Inheritance Biology <ol style="list-style-type: none"> 1. Concept of gene: Allele, multiple alleles, pseudoallele, complementation tests. 2. Mendelian principles: Dominance, segregation, independent assortment, deviation from Mendelian inheritance. 3. Extensions of Mendelian principles: Codominance, incomplete dominance, Lethal and Essential Genes, Anticipation, Penetrance, Expressivity 4. Non-Mendelian Inheritance: Cytoplasmic/maternal inheritance, organelle genetics 	1	15 3 3 5 4
SMSLSC201	2	Regulation of gene expression, Epigenetics, DNA damage and repair <p>Regulation of gene expression:</p> <ol style="list-style-type: none"> 1. Regulation of gene expression in prokaryotes and eukaryotes 2. Transposable elements in bacteria, Insertion segment elements, composite transposons, replicative and non-replicative transposons, Mu transposition, Controlling elements in TnA and Tn10 transposition, short interspersed elements (SINEs) and long interspersed elements (LINEs) <p>Epigenetics, DNA damage and repair:</p> <ol style="list-style-type: none"> 1. Epigenetics: Imprinting, mechanism (Methylation and Acetylation), 	1	15 3 4 3

		2. DNA damage and Repair: Types of DNA damage (Deletion, duplication, inversion, translocation, ploidy and their genetic implications) , DNA repair mechanisms- - nucleotide excision repair, base excision repair, mismatch repair, recombination repair, double strand break repair, transcriptional coupled repair		5
SMSLSC201	3	Molecular Biology/Genetics 1. Microbial genetics: transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating. 2. Quantitative genetics: Pleiotropy and epistasis, polygenic inheritance, heritability and its measurements, QTL mapping 3. Gene mapping methods: Linkage maps and lod score for linkage testing, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids 4. Mutation: conditional, loss of function, gain of function 5. Human genetics: Pedigree analysis, karyotypes using examples, genetic disorders; Human Genome Project and Genome wide association studies.	1	15 3 3 4 2 3
SMSLSC201	4	Techniques in genetics 1. Vectors a. Phages (λ , M13, SV 40, Baculo virus) b. Plasmids (pBR322), Ti plasmids in plants c. Cosmids, YAC, BAC, PAC 2. Screening/ selection techniques – Antibiotic / blue-white screening 3. Gene cloning, transgenic animal and plant production 4. DNA libraries - genomic and cDNA libraries 5. RNase protection assay, microarray 6. Gene therapy: Ex vivo and in vivo therapy, strategies and delivery.	1	15 3 1 3 2 2 4

Reference Books:

- Berg J.M., Tymoczko J.L., and Stryer L., *Biochemistry*, 2006, 6th edition, *Freeman Publishers*, New York.
- Hardin J., Bertoni J.P., Kleinsmith L.J., *Becker's World of the Cell: International Edition*, 2011, 8th Edition, *Pearson Publisher*.
- Nelson D.L. and Cox M.M., *Lehninger Principles of Biochemistry*, 2000, 6th edition. *Worth Publishers*, New York.
- Lewin, B., *Genes IX*, 2006, *Jones and Bartlett Publishers*.
- Pierce B., *Genetics: A Conceptual Approach*, 3rd edition, 2008, *W. H. Freeman & Co.*
- Russell, P.J., *iGenetics- A Molecular Approach*, 3rd edition, 2010, *Pearson Publishers*.
- Snustad & Simmons, *Principals of Genetics*, 6th edition, 2012, *John Wiley & Sons Inc.*
- Read A.P. and Strachan T., *Human Molecular Genetics*, 2010, 4th Edition, *Garland Science*
- Voet D. and Voet J.G., *Biochemistry*, 2010, 4th edition, *Wiley & Sons Publishers*, New York.

SEMESTER II

COURSE CODE: SMSLSC202

PAPER –II CELL BIOLOGY II

Course Objectives:

CO1: To enable understanding of the basics of cell division and cell cycle and molecules in cell cycle regulation.

CO2: To understand cell signaling with examples and cell death processes and pathways involved.

CO3: Introduction to autophagy, its machinery and examples.

CO4: Introduction to techniques in cell cycle analysis, apoptosis, autophagy and cell signalling.

Learning Outcome:

Students will be able to

LO1: Differentiate between different cell cycle stages and gain knowledge about cyclins and cyclin dependent kinases.

LO2: Differentiate between morphological and cellular changes due to necrosis and apoptosis.

LO3: Differentiate between different kinds of cell signalling with the receptors and signal transduction.

LO4: Students will gain knowledge about techniques used in cell biology like TUNEL assay, Comet assay, autophagy marker assay, MTT cell proliferation assay and cell signalling kinase assay

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC202	1	<p>Cell cycle and its regulation</p> <ol style="list-style-type: none"> 1. Cell division: <ol style="list-style-type: none"> a. An overview of prokaryotic and eukaryotic cell division b. Events in M-phase 2. Cell cycle: <ol style="list-style-type: none"> a. Stages of the cell cycle – Interphase (G₀, G₁, S G₂), Mitosis b. Major cell cycle checkpoints c. Role of proteins controlling spindle assembly 3. Embryonic cell cycle- Comparison of embryonic and somatic cell cycle 4. Cyclins & CDK's: <ol style="list-style-type: none"> a. Types and role of Cyclins, CDKs and Cdk inhibitor proteins in regulation b. Importance of Rb/E2F; Role of p53 5. Loss of cell cycle control in relation to cancer <ol style="list-style-type: none"> a. Overview of cancer and genes involved along with their functions b. Mutations causing loss of cell cycle control 	1	<p>15</p> <p>3</p> <p>4</p> <p>1</p> <p>4</p> <p>3</p>

SMSLSC202	2	<p>Cell death and cell survival:</p> <ol style="list-style-type: none"> 1. Necrosis: Morphological and cellular changes due to necrosis 2. Apoptosis: <ol style="list-style-type: none"> a. Apoptosis: morphological changes b. Genes involved in apoptosis: bcl2 family, Caspases, adaptor proteins c. Molecular mechanisms: <ol style="list-style-type: none"> i. Extrinsic pathway ii. Intrinsic pathway iii. Caspase independent (CICD) pathway d. Apoptosis as a physiologically important process in development and maintenance e. Comparison of apoptosis and necrosis <p>Autophagy:</p> <ol style="list-style-type: none"> a. Concept of autophagy b. Basic autophagy machinery c. Autophagy and diseases (any one example) 	1	<p>15</p> <p>1</p> <p>1</p> <p>2</p> <p>4</p> <p>2</p> <p>1</p> <p>4</p>
SMSLSC202	3	<p>Cell signalling</p> <ol style="list-style-type: none"> 1. Overview of types of signalling- endocrine, autocrine, paracrine & nervous system signalling 2. Modes of Cell Signalling- Direct & indirect 3. Types of messengers – hydrophobic and hydrophilic 4. Types of receptors – <ol style="list-style-type: none"> a) Extracellular receptors (ligand-gated receptor, Enzyme coupled receptors, G-protein coupled receptors with examples) b) Intracellular receptors with example c) Regulation of receptors d) Agonist & antagonist of receptors 5. Signal Transduction of the above receptors 6. Regulation of cell signalling and feedback mechanism 	1	<p>15</p> <p>1</p> <p>1</p> <p>1</p> <p>6</p> <p>4</p> <p>2</p>

SMSLSC202	4	Techniques in cell biology II	1	15
				4
				5
				3
				3

Reference Books:

- Alberts B., Johnson A., Lewis J., Morgan D., Raff M., Roberts K., Walter P., Molecular Biology of the Cell, 2007 or 2014, 5th Edition or 6th Edition, *Garland Science Publications*
- Hardin J., Bertoni J.P., Kleinsmith L.J., Becker's World of the Cell: International Edition, 2011, 8th Edition, *Pearson Publisher*
- Karp G., Iwasa J., Marshall W., Cell Biology, 8th Edition, 2013, *Wiley International Publisher.*
- Lodish H., Berk A., Kaiser C.A., Molecular Cell Biology, 2012, 7th Edition, *Macmillan Learning Publications.*
- Paul A., Text book of Cell and Molecular Biology, 2009, Second Edition, *Books and Allied (P) Ltd.*
- Plopper G, Principles of Cell Biology, 2016, 2nd Edition, *Jones and Bartlett Learning Publication.*
- Taylor D.J., Green N.P.O., Stout G.W., Ed. Soper R., Biological Science, 2005, 3rd Edition, *Cambridge University Press.*

SEMESTER II

COURSE CODE: SMSLSC203

PAPER –III SYSTEMS BIOLOGY- II

Course Objectives

CO1 Understand in detail about the Endocrine, Reproductive and Nervous systems.

CO2 Study the concepts of development biology.

CO3 Introduces the details about different types of model systems used in developmental biology.

CO4 Outline the fundamentals of different tools used in systems biology.

Learning Outcomes:

The students will be able to

LO1: Understand the function and organization of Endocrine, Reproductive and Nervous systems.

LO2: Comprehend the different stages of development.

LO3: Inculcate and apply the knowledge of the model system while proposing objectives for their project work.

LO4: Compare, contrast and apply the knowledge of different tools for their project work.

Total: 45 lectures

Course code	Unit	Topic headings	Credits	Lectures	
SMSLSC203	1	Physiology II:	1	15	
		Endocrine system:			
		1. Functions of Endocrine glands (an overview)			1
		2. Biological roles of hormones (protein, glycoprotein and steroid hormones any one example with their mechanism of action)			3
		Reproductive system:			1
		1. Gametogenesis and fertilization			
		2. Zygote formation, implantation, placentation, sex determination			3
		3. Major events in the trimesters of pregnancy			1
		4. Parturition and lactation			
		Nervous system			1
1. General organization of nervous system					
2. Basic functional unit of nervous system					
3. Impulse generation and conduction of nerve impulse	2				
	2				
4. Synaptic transmission: Electrical and Chemical with examples of two neurotransmitters and their receptors	1				
SMSLSC203	2	Physiology III:	1	15	
		Developmental biology:			
		1. Concepts of development: Potency, commitment, specification, induction, competence, determination and		5	

		<p>differentiation</p> <p>2. Early development: cleavage, blastula formation, embryonic fields, gastrulation neurulation</p> <p>3. Introduction to Model systems - <i>Dictyostelium</i> (cell aggregation and differentiation), <i>Drosophila</i> (maternal genes and zygotic genes), <i>C.elegans</i> (cell lineage and cell fate), <i>zebrafish/ hydra</i> (embryogenesis, regeneration)</p>		<p>4</p> <p>6</p>
SMSLSC203	3	<p>Plant Physiology:</p> <p>1. Transport and translocation of solutes</p> <p>2. Role of Diffusion and water potential</p> <p>3. Role of membrane transport proteins</p> <p>4. Phloem loading and unloading</p> <p>5. Function of Plant hormones</p> <p>6. Role of environmental cues during flowering.</p> <p>Plant secondary metabolites and defence Mechanism</p> <p>1. Plant Surface protection compounds: Cutin, Suberin and waxes.</p> <p>2. Secondary metabolites as protectants: Terpenes, phenolic compounds and Alkaloids.</p> <p>3. Hypersensitive responses in plants, synthesis of Phytoalexins, Plant resistance genes (R genes), Systemic acquired resistance</p>	1	<p>15</p> <p>1</p> <p>1</p> <p>1</p> <p>1</p> <p>2</p> <p>2</p> <p>2</p> <p>2</p> <p>3</p>
SMSLSC203	4	<p>Techniques in systems biology II:</p> <p>1. Hormone Replacement Therapy – Benefits and Risks</p> <p>2. ART – IVF and ICSI</p> <p>3. Sonography</p> <p>4. Karyotyping, amniocentesis/ chorionic villi sampling</p> <p>5. Genetic counselling (eg. thalassemia)</p> <p>6. Developmental Biology – fate maps, chimeras, embryo lethal mutants, transient transgenesis</p> <p>7. Plant tissue culture</p>	1	<p>15</p> <p>2</p> <p>2</p> <p>1</p> <p>1</p> <p>1</p> <p>4</p> <p>4</p>

Reference Books:

- Alberts B., Johnson A., Lewis L., Morgan D., Raff M., Roberts K., Walter P., Molecular Biology of the Cell, 5th Edition (2007) or 6th Edition (2014), *Garland Science Publication*
- Delves P., Mastin S. et al, Roitt's Essential Immunology, 2006, 11th Edition, *Blackwell Publishing*.
- Gilbert S.F., Developmental Biology (2016) 11th Edition, *Sinauer Pub.*
- Guyton A.C. and Hall J.E., Text Book of Medical, 2006, 11th Edition, *Elsevier Saunders*
- Kindt, Goldsby, Osborne, Kuby Immunology, 2007, 6th edition, *W. H. Freeman*.
- Mukherjee, Kanai L., Medical Laboratory Technology, 1988, Reprint Edition, *Tata MacGraw Hill Publishing Co. Ltd., New Delhi*.
- Raphael S.S., Lynch's medical laboratory technology, 3rd Edition.
- Seeley R, Stephens T and Tate P, Anatomy and Physiology, 2004, 6th Edition, *The McGraw–Hill Companies*.
- Taiz, Zeiger, Moller and Murphy, Plant Physiology, 2014 6th edition, *Sinauer Publications*.

SEMESTER II

COURSE CODE: SMSLSC204

PAPER –IV EVOLUTION, POPULATION BIOLOGY, BIOSTATISTICS- II AND BIOINFORMATICS

Course objective

CO1: To infer evolutionary concepts and population studies

CO2: To outline fundamentals of biostatistics and bioinformatics

CO3: To introduce students into the world of ‘omics’ with a bioinformatics perspective

Learning outcomes.

The Students will be able to

LO1: To familiarize themselves with various biological databases/tools and their applications

LO2: To understand and analyze sequences and construct phylogenetic trees

Total: 45 lectures

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC204	1	Evolution	1	15
		1. Evidences of evolution- homologous, anatomical, geographical, biochemical, fossil- formation, types of fossils		1
		2. Origin of cells and unicellular evolution: Concept of Oparin and Haldane; Miller's experiment, evolution of prokaryotes and unicellular eukaryotes.		1
		3. Palaeontology and evolutionary history: The evolutionary time scale; eras, periods and epoch; major events in the evolutionary time scale, Trends in human evolution, Social evolution, Molecular palaeontology techniques (protein, DNA, RNA based)		2
		4. Theories of Evolution- Lamarckism, Darwinism- concepts of variation, adaptation, struggle, fitness and natural selection, Mendelism, spontaneity of mutations, the evolutionary synthesis.		4
		5. Species & speciation: concept of species, speciation, isolating mechanisms		2
		6. Molecular Evolution: molecular divergence and molecular clocks, molecular tools in phylogeny.		3
		7. Human genetic disease evolution: BRCAI (Breast cancer), G6PD Deficiency		2

SMSLSC204	2	Population Biology: <ol style="list-style-type: none"> 1. Dynamics, Density, age structure of a population, 2. Population growth, Exponential and Logistic growth, carrying capacity 3. Population Genetics: gene pool, gene frequency, Hardy Weinberg Law and its role in evolution and speciation 4. Ecological interactions: Intra and Interspecific competition, predation, Mutualism, Parasitism, communalism, symbiosis 5. Adaptive dynamics theory, Eco-evolutionary feed back 	1	15 2 3 4 3 3
SMSLSC204	3	Biostatistics II <ol style="list-style-type: none"> 1. Population Statistics: Population parameters and sample statistics, sampling techniques, simple random sampling, stratified random sampling, systematic sampling, standard error of mean. 2. Estimation, point and interval, confidence interval for population, mean and proportion. 3. Hypothesis testing: type-1 and type-2 errors, levels of significance, one tailed and 2 tailed tests 4. Student's t-Test: Paired and unpaired t tests 5. Z-Test: Definition, application, characteristics 6. F-Test: Definition, application, characteristics 7. Analysis of Variance (ANOVA): One-way & Two-way ANOVA 8. Chi-square test: Assumptions & conditions for the use of Chi-square test, test for goodness of fit and test for independence (2x2). 	1	15 2 1 2 2 1 1 3 3
SMSLSC204	4	Structural Bioinformatics and Drug Designing A. Structural Bioinformatics: <ol style="list-style-type: none"> 1. Prediction of protein secondary structure: PHD and PSI-PRED method. 	1	15 1 2

		2. Prediction of Protein Tertiary (3-D) Structure: Fundamentals of the methods for 3D structure prediction (sequence similarity/identity of target proteins of known structure, fundamental principles of protein folding etc.)		3
		3. Homology Modeling, fold recognition, threading approaches, and ab-initio prediction methods.		1
		B. Applications of Bioinformatics		
		1. Drug designing: Drug targets, Lead Identification and Modification, Computer-Aided Drug Design.		3
		2. Chemi-informatics: Introduction and History cheminformatics, Search types, data representation– SMILES, Virtual screening, Quantity Structure Activity Relationship, Applications of cheminformatics		2
		3. Immunoinformatics		
		4. Toxicomics and predictive toxicology		3

Reference Books:

- Arora P.N. & Malhan P.K. Biostatistics, 2002, First Reprint Edition, *Himalaya Publishing House*.
- Banerjee P.K., Introduction to Biostatistics, 2004, First Edition, *S. Chand & Company Pvt. Ltd.*
- Carrol S.B., Remarkable Creatures: Epic Adventures in Search of the Origin of Species, 2009. *Mariner Books*
- Claverie J.M., Notredame C., Bioinformatics for Dummies, 2003, *John Wiley & Sons*
- Gurumani N., An Introduction to Biostatistics, 2011, Second Revised Edition, *M.J.P. Publisher*.
- Hall B. and Hallgrimsson B., Strickberger's Evolution, 2008, 4th Edition, *Jones and Bartlett Publishers*
- Hamilton M.B., Population Genetics, 2009, *Wiley-Blackwell*
- Mahajan B.K., Methods in Biostatistics, 2004, Sixth Reprint Edition, *Jaypee Brothers Medical Publishers (P) Ltd.*
- Ward P., Lamarck's Revenge: How Epigenetics Is Revolutionizing Our Understanding of Evolution's Past and Present, 2018, *Bloomsburg Publishing*.
- Xiong J, Essential Bioinformatics, 2006, *Cambridge University Press*

SEMESTER II

PRACTICAL

COURSE CODE: SMSLSCP201

1. Isolation of plasmid from *E. coli* and transformation of *E. coli* cells.
2. Neutral red staining for apoptosis in developing chick embryo.
3. MTT cell proliferation assay (Demonstration)
4. Assessment of signaling pathways (PKC, IP3 and Calcium) in the regulation of nitrate assimilation in plants/ bacteria.
5. Principle and working of Pregnancy test kit
6. Proline content in normal and saline stressed plants
7. Estimation of Lignin/Flavinoids/Anthocyanin/Alkaloids
8. Estimation of Indole Acetic Acid.

COURSE CODE: SMSLSCP202

Literature Review, Research proposal and preliminary data submission (**MANDATORY**)

COURSE CODE: SMSLSCP203

9. Effect of temperature on *C elegans* development
10. Development of cartilage & bone of *Zebrafish*: Visualization Techniques (Alizarin, Alcian blue)
11. Study life cycle of *Dictyostelium* (Demonstration)
12. Calculation of gene frequency of ABO blood group in human population
13. Calculation of gene frequency due to selection and genetic drift
14. Problems in Genetics a. Problem solving: Multiple alleles, Lethal genes
15. Problem solving: Hardy Weinberg equation, Pedigree analysis.
16. Study of evolution of dental anatomy.
17. Density valuation of *Daphnia* from a given culture
18. Construction of cladogram and phylogenetic tree from a given data set

COURSE CODE: SMSLSCP204

19. Extraction of DNA from brain / neural cell culture (Demonstration)
20. Extraction of RNA from brain / neural cell culture (Demonstration)
21. PCR of gene from neural tissue and demonstration of PCR product using AGE (Demonstration)
22. RFLP analysis of PCR product (Demonstration)
23. Biostatistics: Manual calculation and use of software for Non parametric tests:
 - Median and interquartile range
 - Spearman Rank Correlation
 - Mann Whitney U test

Wilcoxon signed rank test

Kruskal Wallis H test

Concept of logistic regression & ROC curves.

(Analyze the given data using statistical tests that seem appropriate with the help of software and justify the reason for using each test).

24. Bioinformatics:

- i. Protein structure classification: CATH and SCOP
- ii. Secondary Structure: InterProScan/Prosite/JPRED
- iii. Tertiary structure: PDB, Rasmol
- iv. Homology Modelling– SWISS-MODEL, Introduction to docking (protein - protein)
- v. Immunoinformatics: - Epitope mapping
- vi. Detection of post translational modification eg. phosphorylation (in neuro proteins)
- vii. Functional proteomics: -Protein-protein interactions: STRING
- viii. Use of advanced databases: Pubchem, Comparative Toxicogenomics Database

Students are expected to have done the following experiments at the undergraduate level. However, if any student has not been exposed to them, they are expected to perform them prior to commencement of the PG practical.

1. Study of endocrine tissues, Placenta
2. Study of the organization of apical meristems: root and shoot.
3. Permanent slides of different stages of chick embryo
4. Study of types of fossil
5. Basics of databases: NCBI, EMBL, DDBJ

