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 wells 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

Learning Objectives:

To enable understanding of:

- Fundamental thermodynamics, basics of the molecules within the cell and their interactions
- Structure and function of nucleic acids and proteins
- Enzyme kinetics and inhibition
- Molecular process of DNA replication, transcription and translation; and post transcriptional modifications
- Associated techniques in molecular biology

Total: 45 lectures

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC101	**1**	**Cell biochemistry** 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. 2. Energy coupling in mechanical and chemical processes during a chemical reaction. 3. Importance of pH in biology, biological inorganic buffers; Amino acids and Proteins as buffers 4. Metabolism of biomolecules: Synthesis and breakdown of carbohydrates, lipids, amino acids, nucleotides and vitamins (lipid soluble and insoluble) using one typical example each	**1**	**15** 1 1 2 11
SMSLSC101.	**2**	**Nucleic acid biochemistry** 1. Nucleic acid 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) 3. Prokaryotic DNA: Bacterial Circular	**1**	**15** 3 2 1

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

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

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, 11thEdition,*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, 4thEdition, *Garland Science Publisher.*
- Russell, P.J., *i*Genetics- 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 &SonsPublishers, 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

Learning Objectives:

To enable understanding of:

- Microbial diversity and structure of prokaryotic cell
- Microbial growth and its control
- Organelles of eukaryotic cells – structure and function
- Concept of intercellular communication
- The various methods used to study cellular processes

Total: 45 lectures

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC102	**1**	**Biology of Prokaryotes** 1. Viruses: Structure and life cycle of bacteriophage, DNA virus and RNA virus. 2. Microbial diversity: 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; Hyperthermophilicarchaea and Thermoplasma) 3. Prokaryotic Cell Structure- overview 4. Microbial Growth: Growth curve 5. Chemotherapy/Antibiotics: General characteristics of antimicrobial drugs; Antibiotics: Classification, mode of action and resistance; Antifungal and antiviral drugs.	**1**	**15** 3 3 3 3 3
SMSLSC102	**2**	**Biology of Eukaryotes – I** 1. Plasma Membrane Structure, lipid bilayer, membrane proteins 2. Principles of Membrane Transport: Transporters and Active Membrane Transport; Ion Channels and electrical properties of membranes 3. Intracellular Compartments and Protein Sorting: Compartmentalization of cells, Endoplasmic Reticulum, Golgi apparatus and transport from ER to Golgi and lysosomes,	**1**	**15** 2 3 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. *in situ* 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 InternationalPublisher.*
- 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

Learning Objectives:

To enable understanding of:

- Physiological systems that maintain homeostasis-Digestive, Circulatory, Excretory
- Basics of Immunology
- Host Parasite interactions and diseases
- Techniques used in physiology and immunology

Total: 45 lectures

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC103	**1**	**Physiology-I** • 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. **I. Digestive system:** 1. Digestive tract and accessory digestive organs. 2. Digestive processes and an overview of three major nutrients. 3. Gastrointestinal Hormones **II. Circulatory System:** 1. Blood, blood vessels and blood pressure. 2. Anatomy of the heart and its electrical activity. 3. Events associated with cardiac cycle. **III. Excretory system:** 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.	**1**	**15** 3 4 4 4
SMSLSC103	**2**	**Immunology** 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. Study of following infections including Etiology, Transmission, Pathogenesis, Clinical Manifestations, Laboratory diagnosis, Prophylaxis, and Treatment 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	**1**	**15** 2 10 3
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 BIOETHICS, TOXICOLOGY, BIOSTATISTICS I AND RESEARCH METHODOLOGY

Learning Objectives:

The objectives of this course are to enable:

- Understanding of Bioethics in biology
- Apprehend the major classes of toxicology, different toxins, and route of exposure, risk assessment, prediction and management.
- Interpretation of results by using descriptive statistical methods effectively.
- Demonstration and understanding of the central concepts of modern statistical theory and their probabilistic foundation.
- Comprehend and write a scientific research paper.
- Design, execute and statistically analyze experiments using the principles of scientific research methodology.

Total: 45 lectures

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC104	**1**	**Bioethics** 1. Bioethics: Definition – moral, values, ethics and ethics in biology; Role and importance of ethics in biology; 2. Basic Approaches to Ethics; Post humanism and Anti-Post humanism; 3. Bioethics in healthcare, agriculture, modern biology, biotechnology, animal welfare & right / animals in research, wildlife conservation and management, commercialism in scientific research 4. Bioethics and cross-cultural bioethics – Autonomy, Rights, Beneficence, Do No Harm, Justice, Confidentiality, Animal Rights, Environmental ethics, Mixed Perception of Benefit & Risk, 5. Reasoning behind Acceptance or Rejection of Genetic Manipulation, Concerns about Consuming products of GMOs Past and Present 'Bioethical Conflicts' in Biotechnology- Interference with Nature, Fear of unknown, Regulatory concerns, Human misuse 6. Introduction to IPR; Types of Intellectual property – Patents, Trademarks, Copyrights and related rights.	**1**	**15** 2 1 3 3 3 3

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

Reference Books

- Arora P.N. &MalhanP.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., Cresswell 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*.
- GurumaniN., 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

 # 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

Learning Objectives:

To understand:

- Concepts involved in recombination, mutations, repair & regulation of gene expression in bacteria and eukaryotes
- Concepts of inheritance and transposable elements in eukaryotes
- Associated techniques in molecular biology

Total: 45 lectures

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC201	**1**	**Inheritance Biology** 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** **Regulation of gene expression:** 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) **Epigenetics, DNA damage and repair:** 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 StryerL.,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., *i*Genetics- A Molecular Approach, 3rd edition, 2010, *Pearson Publishers.*
- Snustad& Simmons, Principals of Genetics, 6th edition, 2012, *John Wiley & Sons Inc.*
- Read A.P. and Strachnan T.,Human Molecular Genetics, 2010, 4th Edition, *Garland Science*
- Voet D. and Voet J.G., Biochemistry, 2010, 4th edition, *Wiley & SonsPublishers, New York.*

SEMESTER II

COURSE CODE: SMSLSC202

PAPER –II CELL BIOLOGY II

Learning Objectives:

To enable understanding of:

- The basics of cell division and cell cycle.
- Different molecules involved in cell cycle regulation and loss of cell cycle regulation in cells.
- Cell death processes and pathways involved
- Cell signaling using examples
- Techniques which are used in understanding the process of cell cycle, cell death and cell signaling.

Course code	Unit	Topic headings	Credits	Lectures
SMSLSC202	**1**	**Cell cycle and its regulation** 1. Cell division: a. An overview of prokaryotic and eukaryotic cell division b. Events in M-phase 2. Cell cycle: 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: 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 a. Overview of cancer and genes involved along with their functions b. Mutations causing loss of cell cycle control	**1**	**15** 3 4 1 4 3

SMSLSC202	**2**	**Cell death and cell survival:** 1. Necrosis: Morphological and cellular changes due to necrosis 2. Apoptosis: a. Apoptosis: morphological changes b. Genes involved in apoptosis: bcl2 family, Caspases, adaptor proteins c. Molecular mechanisms: 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 **Autophagy:** a. Concept of autophagy b. Basic autophagy machinery c. Autophagy and diseases (any one example)	**1**	**15** 1 1 2 4 2 1 4
SMSLSC202	**3**	**Cell signalling** 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 – 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**	**15** 1 1 1 6 4 2

SMSLSC202	**4**	**Techniques in cell biology II** 1. Cell cycle analyses - Detection of specific cyclins, flow cytometry, MTT cell proliferation assay 2. Apoptosis - Detection of pro- and anti-apoptosis proteins, Detection of DNA fragmentation - TUNEL, COMET assay, Membrane permeability assay/ Phospholipid symmetry (Annexin V staining) 3. Autophagy – markers of autophagy (LC3, Atg8) assays 4. Cell signalling – kinase assays, detection of specific phospho-proteins	**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 Plublication.*
- 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

Learning Objectives:

To enable understanding of:

- Physiological systems that maintain homeostasis-Endocrinology, Reproductive system, nervous system
- Basics of Developmental biology
- Basics of plant physiology
- Techniques in systems biology II

Total: 45 lectures

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

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

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

Learning Objectives:

- To understand:
  - Evolutionary concepts and population studies
  - Fundamentals of biostatistics and bioinformatics
- To familiarize students with various biological databases/tools and their applications
- To enable students to understand and analyse sequences and construct phylogenetic trees
- To introduce students into the world of 'omics' with a bioinformatics perspective

Total: 45 lectures

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

SMSLSC204	**2**	**Population Biology:** 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** 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**	**Bioinformatics** 1. Introduction to bioinformatics and History of bioinformatics 2. Biological databases and their types – Primary and secondary databases, specialized databases, possible	**1**	**15** 1 2

		limitations of databases 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) 4. Multiple sequence alignment - Heuristic approach (progressive alignment, iterative alignment, and block-based alignment) 5. Phylogenetic trees – Molecular evolution, rooted and unrooted trees, phylograms and cladograms, UPGMA, Neighbour Joining Method, Maximum Parsimony. 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 labelling, gel based versus gel free methods) and omics data management (e.g. gene ontology)		3 1 3 2 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*
- GurumaniN., 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: Solving problems using Chi Square test, Students t Test, ANOVA

24. 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. 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