



SOPHIA COLLEGE

(AUTONOMOUS)

Affiliated to the University of Mumbai

Syllabus for Semesters I to II

Program : B.Sc.

Course: Life Sciences

(Choice Based Credit System with effect from the year 2019-20)

SOPHIA COLLEGE (AUTONOMOUS)

F. Y. B.Sc. Life Science Syllabus
(Choice based Credit and Grading System)

Academic year 2019-2020

PAPER –I SEMESTER I

| Course code | Unit | Topic headings | Credits | L / week |
|--------------------|---|----------------------------------|----------------|-----------------|
| Paper I | Cell and Microbial Biology | | | |
| SBSLSC101 | 1 | A Preview of the Cell | 4 | 15 |
| | 2 | Introduction to Microbiology | | 15 |
| | 3 | Microbial growth and its control | | 15 |
| SBSLSCP101 | | Practical | 2 | |
| Paper II | | | | |
| Paper II | Biomolecules and separation techniques | | | |
| SBSLSC102 | 1 | Biomolecules | 4 | 15 |
| | 2 | Molecular Biology | | 15 |
| | 3 | Techniques | | 15 |
| SBSLSCP102 | | Practical | 2 | |

PAPER –I SEMESTER II

| Course code | Unit | Topic headings | Credits | L / week |
|--------------------|--|--|----------------|-----------------|
| Paper I | Eukaryotic cell biology | | | |
| SBSLSC202 | 1 | Nucleus and Cell membrane – Structure and function | 4 | 15 |
| | 2 | Cell Organelles | | 15 |
| | 3 | Cytoskeleton, cell cycle and cell division | | 15 |
| SBSLSCP202 | | Practical | 2 | |
| | | | | |
| Paper II | Classical Genetics, Evolution and Ecology | | | |
| SBSLSC202 | 1 | Genetics- I | 4 | 15 |
| | 2 | Genetics-II | | 15 |
| | 3 | Evolution and Ecology | | 15 |
| SBSLSCP202 | | Practical | 2 | |

SEMESTER I

PAPER –I CELL AND MICROBIAL BIOLOGY

Learning Objectives:

- Learn the basic principles of microbiology
- Learn about types of microscopy to visualize microbial cells
- Understand the differences between prokaryotic and eukaryotic cells
- Study the different types of microorganisms
- Learn about microbial growth and its control

| Paper I | Cell and Microbial Biology | | Credits: 4 |
|-------------|----------------------------|---|---|
| Course code | Unit | Topic headings | L / week |
| SBSLSC101 | 1 | <p>A Preview of the Cell</p> <ol style="list-style-type: none"> 1. Visualization of the cell – Microscopy – Principle, Resolving Power and types of microscopy– Brightfield, Phase contrast, DIC, Fluorescence, Confocal, Electron microscopy –Transmission and Scanning 2. Types and comparison of cells – Bacteria, Archaea and Eukaryotes 3. Limitation on size and compartmentalization of functions 4. Evolutionary origin of organelles and Endosymbiont Hypothesis 5. Overview of Eukaryotic organelles 6. History of Microbiology – Spontaneous generation and Germ theory 7. Role of microorganisms in agriculture, industry and medicine | <p>15</p> <p>3</p> <p>2</p> <p>1</p> <p>2</p> <p>2</p> <p>2</p> <p>3</p> |
| SBSLSC101 | 2 | <p>Introduction to Microbiology</p> <ol style="list-style-type: none"> 1. Viruses, viroid's and Prions <ul style="list-style-type: none"> • Virus – structure and life cycle of a bacterial virus (lytic and lysogenic), animal virus – DNA virus (ex. Herpes virus) RNA virus (plus and minus stranded), Retrovirus and plant virus (TMV) • Viroid's • Prions – e.g. scrapie 2. Prokaryotic cell – Structure Cell wall – Gram positive and Gram negative Nucleoid; capsule / glycocalyx; flagella and endospore 3. Fungi – Growth and reproduction – asexual and sexual 4. Algae – Structural organization 5. Protozoa – Morphological diversity | <p>15</p> <p>5</p> <p>4</p> <p>2</p> <p>2</p> <p>2</p> |

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| SBSLSC101 | 3 | <p>Microbial growth and its control</p> <ol style="list-style-type: none"> 1. Requirements for growth – <ul style="list-style-type: none"> • Physical – Temperature, pH, Osmotic pressure • Chemical – Carbon, nitrogen, sulphur, phosphorus, oxygen, trace elements, growth factors • Biofilm formation • Culture Media • Anaerobic growth 2. Kinetics of growth <ul style="list-style-type: none"> • Binary fission and cell growth • Growth curve and generation time • Batch and continuous cultures • Isolation of microorganisms • Preservation of microorganism 3. Control of microbial growth <ul style="list-style-type: none"> • Physical • Chemical • Antimicrobial | <p>15</p> <p>5</p> <p>6</p> <p>4</p> |
| SBSLSCP101 | Practical | | Credits : 2 |
| | <ol style="list-style-type: none"> 1. Bright field microscopy of stained and unstained samples 2. Measurement of cell size under microscope (concept of mm and μm) 3. Monochrome staining of bacteria, yeast, animal cell (from cheek), plant cell (onion peel) 4. Microbial staining technique: Gram staining; Capsule staining; Endospore staining; cell wall staining 5. Demonstration of Sterilization of laboratory material (principle of use of autoclave) 6. Streak plating of bacterial suspensions (pure culture and soil sample) 7. Slide culture technique for observation of fungi 8. Determination of Minimum Inhibitory Concentration (MIC) of NaCl for a bacterial culture 9. Study of bacterial motility by Hanging drop technique 10. Open ended project | | |

Reference Books:

- Aneja K.R., Experiments in Microbiology, Plant Pathology and Biotechnology, 2017,5th Edition, *New Age International Publishers*.
- Hardin J., Bertoni J.P., Kleinsmith L.J., Becker's World of the Cell: International Edition, 2011, 8th Edition, *Pearson Publisher*.
- Madigan M, Martinko J., Bender K., Buckley D., Stahl D., Brock Biology of Microorganisms, 2017, 14th Edition, *Pearson Publishers*
- Reba Kanungo, Ananthanarayan and Paniker's Textbook of Microbiology,2017, 10th Edition, *Universities Press Publishers*
- Tortora G.J., Funke B.R., Case C.L., Microbiology: An Introduction, 2016, 12th Edition, *Pearson Publication*
- Willey J., Sherwood L., Woolverton C., Prescott, Harley and Klein's, Microbiology, 2008, 7th Edition, *McGraw Hill Higher Education*

PAPER –II BIOMOLECULES AND SEPARATION TECHNIQUES

Learning Objectives:

- To understand the composition of molecules within living cells
- To grasp the principles underlying the techniques of separation of molecules

*Brief History and applications to be included in all the topics

| Paper II | Biomolecules and separation techniques | | Credits: 4 |
|-------------|--|---|---|
| Course code | Unit | Topic headings | L / week |
| SBSLSC102 | 1 | <p>Biomolecules</p> <p>1. Non-carbon-containing molecules in cells:</p> <p>a. Water- the most abundant component</p> <ul style="list-style-type: none"> • Molecular structure and physico-chemical properties • corresponding functions in cells and reasons for it being the basis of life <p>b. Inorganic Ions:</p> <ul style="list-style-type: none"> • Macro-elements- Na, K, Cl, Ca, P, Mg, S • Micro-elements – Fe, Cu Zn, Mn, I, Ni function in cells <p>2. Carbon-containing components in cells:</p> <p>a. Amino acids and Protein macromolecules</p> <ul style="list-style-type: none"> • biological amino acids - general structure and reactions • classification of amino acids based on – biochemical nature and structure • structure-function relation in proteins <p>b. Protein structure and folding, Molecular Chaperones</p> <ul style="list-style-type: none"> • Primary – Quaternary structures within proteins with typical examples • protein folding chaperones and disease <p>c. Monosaccharide Sugars and Polysaccharide Carbohydrates</p> <ul style="list-style-type: none"> • Nomenclature and structure of common sugars <p>d. Fatty Acids and Lipids</p> <ul style="list-style-type: none"> • Nomenclature and structure of common lipids <p>e. Nucleotides and Nucleic Acid Macromolecules</p> <ul style="list-style-type: none"> • Nomenclature and structure | <p>15</p> <p>2</p> <p>1</p> <p>3</p> <p>2</p> <p>2</p> <p>2</p> <p>3</p> |
| SBSLSC102 | 2 | <p>Molecular Biology</p> <p>1. Macromolecular synthesis:</p> <ul style="list-style-type: none"> • DNA synthesis • mRNA, tRNA and rRNA synthesis • Protein synthesis <p>2. Molecular genetics:</p> <ul style="list-style-type: none"> • Concept of the gene- a structural unit of coding • Early experiments that defined the nature of the gene (Griffith's, Avery's and Hershey's Experiments) • Chromatin structure and packaging, Brief introduction to significance in gene expression; epigenetics | <p>15</p> <p>9</p> <p>6</p> |

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| SBSLSC102 | 3 | <p>Techniques</p> <p>1. Extraction techniques</p> <ul style="list-style-type: none"> • Cell lysis techniques – Physical, chemical • Solvent extraction of lipids <p>2. Separation and analytical techniques</p> <ul style="list-style-type: none"> • Precipitation • Filtration • Dialysis • Centrifugation • Chromatography • Electrophoresis <p>Using the above techniques to isolate/ analyse particular molecule using a typical example</p> | <p>15 3</p> <p>12</p> |
| SBSLSCP102 | Practical | | Credits : 2 |
| | | <ol style="list-style-type: none"> 1. Introduction to lab discipline and good laboratory practices. 2. Solution making: <ol style="list-style-type: none"> a. Preparation of solutions of a given chemical compound b. Preparation of dilutions from a stock solution 3. Water molecules and its properties (solvent, density, cohesion and adhesion, colligative properties) 4. pH and its usage: <ol style="list-style-type: none"> a. pH meter b. Making of own pH indicator papers 5. Colorimetry: <ol style="list-style-type: none"> a. Wavelength of maximum absorbance b. Verification of Beer-Lambert's law 6. Study of separation techniques: <ol style="list-style-type: none"> a. Dialysis b. Isoelectric Precipitation of proteins c. Density gradient centrifugation 7. Detection of carbohydrates, proteins, lipids and nucleic acids in vitro and in tissues. 8. Detection of amino acids using chromatography technique 9. Origami and modelling of biochemical structures 10. Extraction of DNA from onion | |

Reference Books:

- Nelson D.L. and Cox M.M., Lehninger- Principles of Biochemistry, 2017, 7th Edition, *W H Freeman & Co Publishers.*
- Plummer M. and Plummer D.T., Introduction to Practical Biochemistry, 1988, 3rd Edition, *McGraw Hill Publication*
- Taylor D.J., Green N.P.O., Stout G.W., Ed. Soper R., Biological Science, 2005, 3rd Edition, *Cambridge University Press.*

SEMESTER II

PAPER –I EUKARYOTIC CELL BIOLOGY

Learning Objectives:

- Learn the structure and function of components of eukaryotic cell
- Understand the structure and role of nucleus and plasma membrane
- Learn about protein formation and trafficking through the endomembrane organelles
- Describe the structure and function of mitochondria and chloroplasts
- Understand the process and mechanism of cell division – mitosis and meiosis

| Paper I | Eukaryotic Cell Biology | | Credits: 4 |
|---|-------------------------|--|------------|
| Course code | Unit | Topic headings | L / week |
| SBSLSC201 | 1 | Nucleus and Cell membrane – Structure and function | 15 |
| | | 1. Nucleus | 5 |
| | | <ul style="list-style-type: none"> • Structure of Interphase nucleus - nuclear membrane, nucleolus, nucleosome model • Euchromatin and Heterochromatin • Specialized chromosomes – polytene and lampbrush chromosomes | 2 |
| | | 2. Membrane – their structure and function History and models of membrane structure | 4 |
| | | 3. Transport across membranes | 3 |
| <ul style="list-style-type: none"> • Transport processes • Simple and Facilitated Diffusion • Active transport – example Na⁺/K⁺ pump • Vesicular transport – Endocytosis and exocytosis | 1 | | |
| 4. Cell adhesion, cell junctions and extracellular structures | 3 | | |
| <ul style="list-style-type: none"> • Cell- cell junctions – tight junctions, gap junctions, adhesion junctions • Extracellular matrix of animal cells – collagen, elastin, laminins | 1 | | |
| 5. Plant cell surface – plant cell wall and plasmodesmata | 1 | | |
| SBSLSC201 | 2 | Cell Organelles | 15 |
| | | 1. Endoplasmic reticulum and ribosomes | 3 |
| | | <ul style="list-style-type: none"> • Ribosomes – structure of prokaryotic and eukaryotic ribosomes and role in protein synthesis • Rough ER – structure and role in protein synthesis – signal peptide hypothesis • Smooth ER – structure and functions (also function as sarcoplasmic reticulum) • ER role in biosynthesis of membranes | 2 |
| | | 2. Golgi Complex | 2 |
| | | <ul style="list-style-type: none"> • Structural organization • Brief introduction to role of Golgi in protein glycosylation and proteasome in protein | 2 |

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| | | <p>degradation</p> <p>3. Lysosomes</p> <ul style="list-style-type: none"> • Formation of lysosomes and role in digestion of materials • Lysosomal storage diseases – silicosis and Tay-Sachs disease <p>4. Peroxisomes</p> <ul style="list-style-type: none"> • Function in animal and plant cells • Zellweger syndrome <p>5. Mitochondria</p> <ul style="list-style-type: none"> • Structure and role in oxidative phosphorylation in ATP synthesis • Mitochondrial DNA and associated disease – LHON <p>6. Plastids</p> <ul style="list-style-type: none"> • Types of plastids • Structure of chloroplast and role in photosynthesis | <p>2</p> <p>2</p> <p>3</p> <p>3</p> |
| SBSLSC201 | 3 | <p>Cytoskeleton, cell cycle and cell division</p> <p>1. Cytoskeleton</p> <ul style="list-style-type: none"> • Types of cytoskeletal elements • Microtubules – Structure and role in spindle formation and cilia/ flagella; microtubule motor proteins • Microfilaments – Structure and role in muscle contraction and motility (migration via lamellipodia/amoeboid movement/cytoplasmic streaming) • Intermediate filament – Structure and functions <p>2. Cell cycle</p> <ul style="list-style-type: none"> • Cell cycle stages • Regulation of Cell cycle (in brief – role of cyclins and Cdks) • Cancer as an example of dysregulation of cell cycle <p>3. Cell Division</p> <ul style="list-style-type: none"> • Mitosis stages and cytokinesis, Metaphase chromosomes: centromere and kinetochore, telomere and its maintenance • Meiosis – Stages and significance – crossing over | <p>15</p> <p>5</p> <p>4</p> <p>5</p> |

| SBSLSCP201 | Practical | Credits : 2 |
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| | <ol style="list-style-type: none"> 1. Electron micrographs of organelles and junctions 2. Barr body from buccal smear 3. Cytoplasmic streaming in plant cells 4. Mitosis from onion root tip 5. Permanent slides of meiotic stages 6. Staining of striated muscle 7. Plasmolysis using Tradescantia leaf 8. Methyl green pyronin staining for localisation of nucleic acids | |

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, Cell Biology, 2013, 7th Edition- International Student Edition, *Wiley Publication.*
- Lodish H., Berk A., Kaiser C.A., Molecular Cell Biology, 2012, 7th Edition, *Macmillan Learning Publications.*
- 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.*

PAPER –II Classical Genetics, Ecology and Evolution

Learning Objectives:

- To understand the history and basics of modern genetics
- To grasp the influence of environment on survival of organisms along with theories on origin of life and evolution

| Paper II | Classical Genetics, Evolution and Ecology | | |
|-------------|---|---|---|
| Course code | Unit | Topic headings | L / week |
| SBSLSC202 | 1 | <p>Genetics</p> <ol style="list-style-type: none"> 1. Science of Genetics – Overview and history of Modern Genetics, Thomas Hunt Morgan’s Experiment 2. Mendelian inheritance Herman’s experiment on X-ray induced mutations- Concept of homozygous, heterozygous, phenotype, genotype, alleles; Mendel’s Laws and Mono and Dihybrid ratios with problems, chi square - for 3:1 and 1:1 ratio. Use sickle cell anaemia as an example to explain the concept of gene 3. Modification of Mendel’s laws - Gene interactions: incomplete dominance, co-dominance; Multiple genes, Multiple alleles: Blood group, Epistasis, Linkage, Sex- limited, sex influenced. 4. Non-Mendelian inheritance - Evidences for Cytoplasmic factors, cytoplasmic inheritance, extranuclear inheritance (mitochondrial, chloroplast), non-chromosomal inheritance, maternal inheritance, uniparental inheritance. 5. Pedigree analysis - Symbols of Pedigree, Pedigrees of Sex-linked and Autosomal (dominant and recessive). | <p>15</p> <p>3</p> <p>4</p> <p>3</p> <p>3</p> <p>2</p> |
| SBSLSC202 | 2 | <p>Genetics</p> <ol style="list-style-type: none"> 1. Chromosome Theory - Chromosome Theory of Heredity (Sutton-Boveri), Inheritance patterns, phenomenon of Dominance, Inheritance patterns in Human (Sex-linked, Autosomal), Mechanisms and significance of crossing over. 2. Chromosomal anomalies – Structural: deletion, duplication, inversion, translocation. Numerical: euploidy and aneuploidy (e.g. Downs, Turners, Klienfelter’s, Cri-du-chat). 3. Allelic Variation and Gene function - Non-Epistatic inter-allelic genetic interactions, Atavism/Reversion, | <p>15</p> <p>3</p> <p>3</p> <p>5</p> |

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| | | <p>Penetrance (complete and incomplete), Expressivity, Pleiotropism.</p> <p>4. Applications - scope of genetics using genetic traits in plant and animal breeding, gene mapping, disease and congenital defect prediction, evolutionary trends.</p> <p>5. Branches of genetics.</p> | <p>3</p> <p>1</p> |
| SBSLSC202 | 3 | <p>Ecology and Evolution</p> <ol style="list-style-type: none"> 1. Organism and its environment: Distribution and abundance of Organisms, Importance of carbon-based life. Concept of Ecosystem. 2. Biotic Environment: Population, population density, Reproduction, Population growth (Natality, Mortality) Extinction of Population. 3. Interspecific and Intraspecific Population Regulation: Competition, Dispersal, Territoriality, Predation. (Lotka-Volterra model), Parasitism, Mutualism. 4. Theories of Origin of Life <ol style="list-style-type: none"> a. Spontaneous generation Vs. Biogenesis, other theories (special creation/steady state /Cosmozoan theory) b. Biochemical evolution (Alexander Oparin and Stanley Miller) 5. Lamarkian Evolution | <p>15</p> <p>3</p> <p>3</p> <p>4</p> <p>4</p> <p>1</p> |
| SBSLSCP202 | Practical | | Credits : 2 |
| | | <ol style="list-style-type: none"> 1. Pairing game to produce a Punnett square. 2. Meiosis from <i>Tradescantia</i> (demonstration/ Photograph) 3. Collection of blood group information from family and construction of pedigree charts 4. Evolution card 5. Adaptive radiation using <ol style="list-style-type: none"> a. Darwin finches b. Mouth parts in insects- mosquito, housefly and cockroach. 6. Animal Biodiversity: <ol style="list-style-type: none"> a. Part I: Classification of Animals – Invertebrates b. Part II: Classification of Animals – Vertebrates c. Digital recording and detailed classification of one animal from campus/ local environment 7. Biostatistics: <ol style="list-style-type: none"> a) Purpose of Biostatistics: Data collection, Discrete and continuous variables, qualitative and quantitative Biostatistics. b) Study of Class Intervals and calculation of frequency, Representation – tabular and graphical – line graph, | |

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| | <p>frequency curve, Ogive curve, histogram and pie diagram. (Also represented using computers – Excel),</p> <p>c) Measures of central tendency – mean, median, mode and standard deviation,</p> <p>d) Chi square problems for monohybrid and dihybrid crosses</p> <p>8. Localization of lipid globules, starch grains using potato/groundnut</p> <p>9. Perform a search on any one topic using PubMed, download about ten abstracts and prepare a summary of the literature.</p> | |
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Reference Books:

- Brooker, Widmaier, Graham, Stiling, Biology, 2016, 4th edition, *McGraw-Hill Education Publication*
- Campbell, Reece, Urry, Cain, Wasserman, Minorsky, Jackson, Biology, 2016, 11th Edition, *Pearson Publication*
- Freeman S., Biological Science, 2004, Benjamin Cummings Publishing Company.
- Hyde D. R., Genetics and Molecular Biology: With Fundamentals of Biostatistics, 2010, 1st Edition, *McGraw Hill Education Publication*
- Russelle P., *iGenetics: A Molecular Approach*, 2010, 3rd Edition, *Pearson Benjamin Cummings Publications.*
- Simon E.J., Biology: The Core, 2016, 2nd Edition, *Pearson Publication.*
- Ward P., Lamarck’s Revenge: How Epigenetics Is Revolutionizing Our Understanding of Evolution's Past and Present, 2018, *Bloomsburg Publishing.*