St. Xavier's College (Autonomous),

Mumbai

Syllabus of the courses offered by the Department of Life Science and Biochemistry (2018-19)

St. Xavier's College – Autonomous Mumbai

Syllabus
For 7th Semester Courses in
M.Sc. Life Science
(June 2018 onwards)

Contents:

Syllabus (Theory and Practical) for Courses:

Template for theory and practical question paper

LIFE SCIENCE

M.Sc. **Course No.: SLSC701**

Title: Cell Biology

Learning Objectives:

On completion of the course, the student must be able to:

1. Understand the structure and function of components of eukaryotic cells - membranes, organelles and cytoskeleton
2. Describe the various types of cellular transport involved in movement of material into the cell and between various compartments of the cell.
3. Explain the concept of intercellular communication using diffusible solutes and cell membranes
4. Enlist stages of cell cycle and discuss the basis of its regulation
5. Summarize the causes and regulation of programmed cell death
6. Compare & contrast the various methods used to study cellular processes

Number of lectures: 60

UNIT I **(15 lectures)**

1. Origin and Evolution of Cells **(1)**
2. Limits of cellular compartment - The Plasma Membrane **(3)**
3. Sub-cellular compartmentalization (with reference to evolutionary origin, structure, and function) (Guided self-study) **(4)**
   a. The Endomembrane System – ER, Golgi apparatus, Lysosome, Vacuole, Peroxisome
   b. Mitochondria
   c. Chloroplast
   d. Nucleus
4. Cytoskeletal Organization **(6)**
   a. Microtubules, Microfilaments & Intermediate filaments : types, structure and function
   b. The cytoskeleton and cell behaviour : cilia, flagella; cytokinesis
5. Motor proteins – prototype structure & role in cellular cargo transport **(1)**

UNIT II **(15 lectures)**

1. Membrane Transport **(6)**
   a. Passive diffusion
   b. Facilitated diffusion
   c. Active transport – primary & secondary
   d. Transport of ions
   e. Endocytosis, Exocytosis, Bulk transport
2. Vesicular Transport Pathways **(6)**
   a. ER to Golgi,
   b. Golgi to plasma membrane/ secreted out
   c. Golgi to lysosomes
3. Signal Sequences in Protein Targeting: nuclear, mitochondrial and chloroplast **(1)**
4. Overview of Protein Degradation Pathways **(2)**

UNIT III **(15 lectures)**

1. Cell signalling **(9)**
   a. Concept of signal transduction
   b. Receptor types –G-protein receptor, enzyme coupled receptors (tyrosine kinase, ser-thr kinase), ionotropic receptors
   c. Signalling pathways – Adenylate Cyclase-cAMP, IP3-DAG, Calcium/Calmodulin
2. Intercellular interactions **(6)**
   a. Cell junctions – need & organization
   b. Types of junctions – composition & function of occluding & adherens junctions, communicating junctions
   c. Cell-ECM interactions – Integrins & cell anchoring

UNIT IV **(15 lectures)**

1. Cell Cycle and its Regulation **(7)**
   a. An overview of Cell Cycle
   b. Cyclin and Cyclin-dependant kinases, Cdk inhibitor proteins
   c. Cell Cycle Check points
   d. Cell Division – Mitosis & Cytokinesis; Meiosis
2. Apoptosis **(8)**
   a. Cellular changes underlying apoptosis, Apoptosis-dependent developmental/physiological processes
   b. Apoptotic pathways : Extrinsic and Intrinsic Pathways
   c. Caspases as executioners of apoptosis, DNA fragmentation regulators.
   d. Techniques for apoptosis detection : TUNEL, COMET assay, Flow Cytometry based assays
   e. Imbalance between proliferation and apoptosis – Endometrial Hyperplasia, neoplasia

References:

1. Alberts B (2016) 'Molecular Biology of the Cell' *Garland Science.*
2. Karp G (2013) 'Cell Biology' *Wiley.*
3. Lodish H (2016) 'Molecular Cell Biology' *W. H. Freeman & Co.*
4. Cooper G (2015) 'The Cell: A Molecular Approach' *Sinauer Associates Inc.*
5. Watson J (2017) 'Molecular Biology of the Gene' *Pearson.*
6. Nelson D and Cox M (2017) 'Lehninger Principles of Biochemistry' *W. H. Freeman & Co.*
7. Voet D, Voet J and Pratt C (2016) 'Fundamentals of Biochemistry' *Wiley.*

LIFE SCIENCE

M.Sc. **Course No.: SLSC702**

Title: Scientific communication, Research methodology, Intellectual Property Rights, Entrepreneurship

Learning Objectives:

The objectives of this course are to enable a student to:

1. Comprehend and write a scientific research paper.
2. Use scientific software to analyze and present data for research.
3. Design, execute and statistically analyze experiments using the principles of scientific research methodology.
4. Understand Intellectual property rights and patent law applicable to bio-entrepreneurship.
5. To convert an idea into a viable business model for entrepreneurship.

Number of lectures: 60

UNIT I: Communication Skills (15 lectures)

1. Introduction to the structure of a scientific research paper
2. Reading a scientific research paper and construction of an abstract
3. Usage of software in writing research paper (to construct graphs, bibliography, etc.)
4. Writing a scientific research paper
5. Designing a poster/ MS-Powerpoint presentation from a paper.

UNIT II: Research Methodology (15 lectures)

1. Introduction - Basic research, Applied research, Need-based research
2. Identifying and defining the problem
3. Planning a research project
4. Literature search - information sources, library resources - books, journal, abstracts hand books, procedure manuals, encyclopaedia, annual reports, data banks, CDROMS, online literature search - internet access, websites, directories of information resources
5. Experimental design - approaches to research design - descriptive, correlational, experimental, semi-experimental, meta-analysis, pilot study
6. Progress of research - Research communication - use of statistical tools in presentation of research findings, need for peer-review, publication of research findings (impact factor, citation index)

UNIT III: Intellectual Property Rights (15 lectures)

1. Intellectual property rights: meaning, evolution - classification and forms
2. Rationale for protection of IPRs - importance of IPRs in the fields of science and technology
3. Patents - concepts and principles of patenting - patentable subject matter (Biotechnology and IPR - microorganisms as inventions, plant varieties, food security, genetic engineering, biodiversity, bioinformatics software protection, sharing of biological R&D material)
4. Procedure for obtaining patents - rights of patents - infringement of patent rights
5. Remedies for infringement of patent right - Patentability and emerging trends (National and International scenario - IPO, TRIPs)

UNIT IV: Entrepreneurship **(15 lectures)**

1. Concept, definition, structure and types of entrepreneurship
2. Process of entrepreneurial development
    a. Planning a New Enterprise
    b. Policies and Schemes
    c. Entrepreneur competency (leadership)
3. Product planning and development
    a. Concept of projects, project management
    b. Search for business idea - opportunity identification, project selection and formulation
    c. Design and network analysis - Institutional interphase for enterprise
    eg. Entrepreneurship Development Institute of India (EDII), Small industries, Service institute, Banks and financial institutions
    d. Project report and project appraisal (case study)
4. Ethical decision making, ethical dilemmas

References:

1. Robert A. Day, Barbara Gastel. (2011) "How to Write & Publish a Scientific Paper" *Greenwood*.
2. Vernon Booth, (2003) "Communicating in Science: Writing a Scientific Paper and Speaking at Scientific Meetings" *Cambridge University Press*.
3. Janice R. Matthews, Robert W. Matthews "Successful Scientific Writing: A Step-By-step Guide for the Biological and Medical Sciences" *Cambridge University Press*.
4. Purdue OWL and other online resources.
5. John W. Creswell, J. David Cresswell (2017) "Research Design: Qualitative, Quantitative, and Mixed Method Approaches" *Sage*.
6. Petter Laake, Haakon Breien Benestad, Bjorn Reino Olsen (2015) "Research Methodology in the Medical and Biological Sciences" *Elsevier*.
7. N Gurumani (2006) "Research Methodology for Biological Sciences" *MJP Publishers*.
8. Geoffrey Marczyk, David DeMatteo, David Festinger (2005) "Essentials of Research Design and Methodology" *John Wiley and Sons, Inc*.
9. Desai V (2011) "Small-Scale Industries and Entrepreneurship" *Himalayan Publishing House*.
10. Collins Ipand Lazier W (1992) "Beyond entrepreneurship" *Prentice Hall*.
11. Ganguli,P (2001) "Intellectual Property Rights" *Tata McGraw Hill.*

LIFE SCIECE

M.Sc. **Course No.: SLSC703**

Title: Biochemistry

Learning Objectives:

On completion of the course, the student must:

1. Know the various physical forces that exist between molecules, the relative movements and interactions that arise due to these forces and the theories that explain them.
2. Understand fundamental thermodynamics and free energy changes that drive biochemical reactions.
3. Acquire a clear understanding of protein structure and folding, and its relation to protein function.
4. Comprehend enzyme kinetics and inhibition, and the role of coenzymes in enzyme function.
5. Understand metabolism, hormonal regulation and the association of metabolic disorders with biomolecules.

Number of lectures: 60

UNIT I **(15 lectures)**

1. Introduction to Forces in Biology **(6)**
   a. Van der Waals forces.
   b. Electrostatic and double layer forces (DLVO theory).
   c. Hydration and hydrophobic forces.
   d. Polymer-mediated tethering forces (steric, bridging and depletion forces).
   e. Formation of micelles and liposomes.
2. Concepts of Solute Movement in Cells and Tissues **(3)**
   a. Brownian motion.
   b. Diffusion and osmosis.
   c. Viscosity (Reynolds numbers, motors and propulsion).
3. Thermodynamics **(6)**
   a. Free energy- standard free energy and its relation to temperature & pressure.
   b. Near equilibrium conditions for biochemical reactions.
   c. Redox reactions & high energy phosphate bonds.

UNIT II **(15 lectures)**

1. Protein structure– primary,secondary,super-secondary,tertiary & quaternary structure. **(3)**
2. Protein folding : **(6)**
   a. Levinthal paradox
   b. Models of protein folding
   c. Role of GroEL-ES system in *in vivo* protein folding
3. Supramolecular assembly – T-even phage /Lipid Bilayer / Quadruplex DNA/ Protein or enzyme assembly **(2)**
4. Co-operativity in protein function – Hb – O_2 binding, muscle contraction. **(2)**
5. Function of multi-subunit protein – ATCase enzyme / PFK enzyme. **(2)**

UNIT III **(15 lectures)**

1. General principles of enzyme catalysis – acid-base, covalent, metal-ion assisted. **(2)**
2. Kinetics of single substrate enzyme-catalysed reactions: **(3)**
   a. Michaelis-Menten equation, Kinetic studies using MM plot
   b. Lineweaver Burk plot and Eadie Hofstead plot
3. Kinetics of allosteric enzyme-catalysed reactions: Hill's equation, Hill's coefficient and its significance. **(2)**
4. Enzyme inhibition: reversible, irreversible, allosteric **(2)**
   (Competitive, Uncompetitive, Non-competitive)
5. Role of coenzymes in enzyme function: Mechanism of action of any 2 coenzymes, **(3)**
   Examples of reactions involving all the coenzymes derived from water soluble vitamins.

UNIT IV **(15 lectures)**

1. Basic cellular metabolism (schematics only). **(9)**
   a. Carbohydrates: Glycolysis, HMP shunt, TCA cycle, Gluconeogenesis, Glycogen metabolism
   b. Lipids: Synthesis and breakdown of TAGs & fatty acids; synthesis and utilization of ketone bodies and their significance in pregnancy, diabetes mellitus, starvation , alcoholism and in weight loss programs
   c. Amino acids: Deamination, transamination, Urea cycle, inborn errors in the metabolism of amino acids(Phenylketonuria/Alcaptonuria)
   d. Significance of ATP in metabolism
2. Hormonal regulation and integration of metabolism. **(1)**
3. Metabolic disorders (as guided study/assignments/presentations) **(2)**
   For example: Diabetes mellitus (endocrine), Hepatic dysfunction (alcohol-induced cirrhosis), Anorexia (psychosomatic), Dyslipidemia/ Hypercholesterolemia (dietary)]]
4. Physiological role of Fat soluble vitamins and disorders associated with their deficiency/excess **(3)**

References

1. Gilbert HF (1992) "Basic Concepts in Biochemistry: A Student's Survival Guide" *McGraw-Hill*.
2. JM Berg, JI Tymoczko, L Stryer, GJ Gatto, Jr. (2010) "Biochemistry" *WH Freeman and Company*.
3. Nelson D and Cox M (2017) 'Lehninger Principles of Biochemistry' *W. H. Freeman & Co.*
4. Voet D, Voet J and Pratt C (2016) 'Fundamentals of Biochemistry' *Wiley.*
5. N Price and L Stevenson (2000) "Fundamentals of Enzymology: The Cell and Molecular Biology of Catalytic Proteins" *Oxford University Press*.
6. M Dixon and EC Webb (1964) "Enzymes" *Academic Press*.
7. Quarterly Reviews of Biophysics 34, 2 (2001), pp. 105–267. 2001 Cambridge University Press. DOI: 10.1017/S0033583501003687 Printed in the United Kingdom

LIFE SCIENCE

M.Sc. **Course No.: SLSC704**

Title: Laboratory Management and Analytical Techniques

Learning Objectives:

To introduce the students to:

1. Basic clinical laboratory setup as well as GLP and accreditations
2. Various approaches used in the study of biological samples.
3. The principles of separation and investigation applied to analysis of biological samples.
4. Current trends in calibrations and certifications association with instrumentation techniques (to be covered in practicals).

UNIT I: Laboratory setup and management **(15 Lectures)**

1. Introduction to Clinical Laboratory **(8)**
    a. Standard Clinical Laboratory set up
    b. General Safety guidelines
    c. Decontamination and Disinfection.
    d. Sterilization techniques
    e. Hazard analysis, Safety Data Sheets, and First Aid Kit.
2. Total Quality Management: **(7)**
    a. Quality Control mechanisms, (Internal and External)
    b. Preparation of lab report and cataloguing.
    c. Basic principles of accreditation of labs, (ISO and NABL).
    d. GLP

UNIT II: Separation methods **(15 Lectures)**

Principle, instrumentation and application in biomolecular analysis of

1. Chromatography **(6)**
    a. Column, thin layer, paper, adsorption
    b. Partition, ion exchange, affinity chromatography, Size exclusion
    c. HPLC, GC, Reverse Phase
2. Electrophoresis **(5)**
    a. Agarose, SDS PAGE, Capillary Electrophoresis
    b. 2D PAGE, Pulse Field Gel Electrophoresis
    c. Western Blot, Southern Blot
3. Centrifugation **(4)**
    a. Factors affecting centrifugation
    b. Differential centrifugation
    c. Density gradient
    d. Analytical centrifugation

UNIT III: Techniques based on Microscopy and Electromagnetic Spectrum

(15 Lectures)

Principle, instrumentation and application of

1. Microscopy **(7)**
    a. Light microscopy, Dark Field, Phase Contrast, DIC
    b. Fluorescence, Confocal microscopy
    c. Electron Microscopy (Scanning and Transmission), specimen preparation, Cryo TEM
    d. Scanning Probe microscopy (AFM)
2. Spectrometry **(8)**
    a. Colorimeter and UV-Visible spectrophotometer, Beer-Lamberts Law
    b. Qualitative and quantitative methods of analysis-protein estimation methods, Hypo and hyper-chromicity coupled assays
    c. Fluorescence and Luminescence analysis
    d. Turbidimetry

UNIT IV: Techniques for composition, sequence or structure determination

(15 lectures)

Principle, instrumentation, technique and application of

1. Atomic absorption and emission spectroscopy **(2)**
2. ORD/CD spectroscopy **(1)**
3. IR and Raman Spectroscopy **(2)**
4. Mass Spectroscopy (Biomolecules) **(3)**
5. X-Ray Diffraction **(3)**
6. NMR spectroscopy **(2)**
7. Next Generation Sequencing for Nucleotides **(2)**

References:

1. Godkar, P.B. Godkar, P.D. (2014) "Textbook of Medical Laboratory Technology (Set of 2 Volumes): Clinical Laboratory Science and Molecular Diagnosis" *Bhalani Publishing House*.
2. Skoog, D.A., Holler, F.J., Crouch S.R. (2018) "Principles of Instrumental Analysis" *Cengage Learning*.
3. Sheehan, D. (2010) "Physical Biochemistry: Principles and Applications" Wiley-Blackwel.
4. Garcia L.S. (2014) "Clinical Laboratory Management" *American Society for Microbiology Press*.
5. McPherson R.A., Pincus, M. R. (2017) "Henry's Clinical Diagnosis and Management by Laboratory Methods" *Elsevier*.
6. Manz, A., Dittrich, P.S., Pamme, N., Iossifidis, D. (2015) "Bioanalytical Chemistry" *Imperial College Press*.
7. Schalkhammer, Thomas G.M. (2002) "Analytical Biochemistry" *Springer (India) Private Limited*
8. Cooper, T.G. (2009) "The Tools of Biochemistry" *Wiley*.

9. Spector, David L. & Goldman, R.D. (2006) "Basic Methods in Microscopy: Protocols And Concepts From Cells: A Laboratory Manual" Cold Spring Harbor Laboratory Press.
10. Pawley, James B. (2006) "Handbook of Biological Confocal Microscopy" *Springer Science Plus Business Media*.
11. Chandler, Douglas E. & Roberson, Robert W. (2009) "Bioimaging: Current Concepts in Light and Electron Microscopy" *Jones and Bartlett Publishers*.
12. Wilson, K. & Walker, J. (2013) "Principles and Techniques of Biochemistry and Molecular Biology" *Cambridge University Press.*

Practicals:

Course: SLSC7PR

Protein Biochemistry and Biostatistics

1. General Laboratory Instructions, Safety and Rules

2. Making of Solutions.

3. Calibration, Accuracy and Precision
   a. Quality assurance; IQ, OQ, PQ and DQ
   b. GLP and GMP compliance
   c. Classification of Instrumental methods
   d. Methods of expressing accuracy and precision
   e. Calibration of Micropipettes, Glass pipettes and other Measuring containers.

4. Use of general lab instruments and their calibration and care: pH meter, Balance etc.

5. Study of Henderson-Hasselbach Equation and calculations for Buffer preparation

6. Estimation of Protein by various methods. Comparison of the sensitivity of estimation methods

7. Comparison of different methods for cell-lysis (yeast cells/bacterial cells and estimation of protein content in cell free supernatant)

8. Protein Purification: extraction and semi-purification of an enzyme (Beta-Amylase/Acid Phosphatase/ beta-galactosidase)
   a. Crude enzyme assays and determination of optimum conditions
   b. Cell lysis
   c. Ammonium sulfate fractionation and dialysis
   d. Column chromatography (Ion exchange/ Gel filtration)
   e. Determination of Specific activity.
   f. Enzyme kinetics
   g. Effect of inhibitors on enzyme reaction
   h. Immobilization of enzyme/ yeast (invertase) and determination of enzyme activity

9. Electrophoresis of Proteins
   a. Native PAGE (Activity staining: LDH/Amylase)
   b. SDS PAGE (CBB/ Silver Staining)
   c. Demonstration of Western Blot

Template of Theory Question paper
M.Sc. Life Science
701, 702, 703, 704

CIA I – 20 marks, 45 mins.
Objectives/Short questions

CIA II – 20 marks, 45 mins.
Test/ Survey/ Assignment/ Presentation/ Poster/ Essay/ Review

End Semester exam – 60 marks, 2 hours
Choice is internal- within a unit and could be between 50% to 100%

M.Sc. Life Science
Practical Evaluation
Course: SLSC7PR

CIA & End Semester Practical Exam	**Total marks: 200**
CIA	80 marks
ESE	120 marks

For CIA: (20 marks journal + 60 marks experiments/viva etc)

St. Xavier's College – Autonomous Mumbai

Syllabus
For 8th Semester Courses in
M.Sc. LIFE SCIENCE
(June 2018 onwards)

Contents:
Syllabus (theory and practical) for Courses:

Template for theory and practical question paper

LIFE SCIENCE

M.Sc. **Course No.: SLSC801**

Title: Human Physiology I

Learning Objectives:
The course aims at:
1. Imparting knowledge and understanding of the structural organization of the human body and its functional segregation into various systems, and understand the physiological interdependence of various systems.
2. Introducing the students to the physiological and cellular mechanisms underlying disorders of various organ systems.

Number of lectures: 60

UNIT I **(15 lectures)**

1. **Introduction to Physiology:** Structural and functional organization of the human body; General characteristics of homeostatic control systems. **(3)**
2. **Gastrointestinal Physiology:** Overview of digestive process; Secretory functions of the alimentary canal; Cephalic, gastric and intestinal phase of stomach secretion; Digestion and absorption in the G.I. tract; Role of accessory glands – liver, pancreas, gall bladder; Neural and endocrine control of GI function; Overview of the absorptive and Post-absorptive state; Basal Metabolic Rate. **(6)**
3. **Disorders of the GI system:** Liver Cirrhosis, Obesity, Vitamin deficiencies **(6)**

UNIT II **(15 lectures)**

1. **Cardiovascular system:** Anatomy of the heart; Blood flow through the heart; Cardiac cycle; Rhythmic excitation of the heart. **(5)**
2. **Circulatory system:** Components of blood; Blood flow and resistance; Functions of the arterial and venous system; Cardiac output and venous return; Humoral and nervous control of circulation; Blood pressure control. **(5)**
3. **Lymphatics** **(1)**
4. **Cardiovascular disorders:** Atherosclerosis, Cardiac arrhythmia, Anaemia, Thalassemia. **(4)**

UNIT III **(15 lectures)**

1. **Urinary system:** Physiologic anatomy of the Kidneys; Overview of the process of urine formation – Glomerular filtration, Tubular reabsorption, Tubular secretion; Micturition reflex; GFR and Renal Blood flow; Neural control and Auto-regulation of GFR and Renal Blood Flow. **(7)**
2. **Disorders:** Acute and chronic renal failure **(2)**
3. **Physiology of Muscle Contraction:** Gross anatomy of skeletal, smooth muscles and cardiac muscles; Molecular mechanism of muscle contraction. **(4)**
4. Neural control of muscle contraction: the Neuromuscular Junction. **(2)**

UNIT IV **(15 lectures)**

1. **Respiratory system:** Overview of the respiratory system; Pulmonary ventilation; Measuring lung function – Lung Compliance, Pulmonary Volumes and Capacities; Principles of gaseous exchange; Relationship between Pulmonary ventilation and Pulmonary capillary blood flow; Transport of gases in the blood - Hemoglobin and oxygen transport; Carbon dioxide and blood pH; Neural and chemical control of ventilation. **(7)**
2. **Respiratory disorders:** Chronic Obstructive Pulmonary Disorders, Cystic fibrosis **(4)**
3. **Musculoskeletal disorders:** Osteoporosis, Osteoarthritis, Duchenne's Muscular Dystrophy **(4)**

References:

1. Arthur C. Guyton, John E. Hall (2006) "Textbook of Medical Physiology" *Elsevier Saunders*.
2. Ken Saladin (2003) "Anatomy & Physiology: The Unity of Form and Function" *The McGraw−Hill Companies*.
3. Seeley R, Stephens T, Tate P (2004) "Anatomy and Physiology" *The McGraw−Hill Companies*.
4. Stuart Fox (2003) "Human Physiology" *The McGraw−Hill Companies*.
5. Rhodes R, Tanner G (2003) "Medical Physiology" *Lippincott Williams & Wilkins*.

LIFE SCIENCE

M.Sc. **Course No.: SLSC802**

Title: Basic Mathematics and Biostatistics

Learning Objectives:

1. To equip students with mathematical and statistical concepts and methods.
2. To introduce students to the display and communication of statistical data. This will include graphical and exploratory data analysis.
3. To help students understand estimation, testing and interpretation for single group summaries such as mean, median, variance, correlation and regression.
4. To promote an understanding of the basics of hypothesis testing, confidence intervals and the interpretation and application of commonly used statistical tests – Z, t, Chi square.
5. To aid in the understanding of the basic concepts of ANOVA.

Number of lectures: 60

UNIT I **(15 lectures)**

1. Matrices and determinants **(5)**
2. Limits and derivatives **(5)**
3. Differential equations **(5)**

UNIT II **(15 lectures)**

1. Collection, tabulation and graphical representation of data, frequency distribution. **(2)**
2. Measures of central tendency (for grouped & ungrouped data) **(3)**
3. Skewness and Kurtosis **(1)**
4. Measures of dispersion **(3)**
5. Concept of sampling, sampling techniques, standard error **(3)**
6. Simple correlation and regression **(3)**

UNIT III **(15 lectures)**

1. Concepts of Probability **(1)**
2. Theories of Probability – Additive and multiplicative theory **(2)**
3. Binomial, Poisson and Gaussian (Normal)distribution **(2)**
4. Measure of location (Z score, percentile rank and percentile) **(2)**
5. Hypothesis Testing - Null hypothesis, Alternative hypothesis, Levels of significance, Type I , Type II error, Critical region **(2)**
6. Test of significance of Mean :(Z test and t test), Test for proportion **(6)**

UNIT IV **(15 lectures)**

1. One-way ANOVA, Tukey's post hoc test **(3)**
2. Two-way ANOVA **(4)**
3. Design of experiment : randomized design, randomized block and factorial experimental designs **(3)**
4. Non- parametric tests- Chi-square test of goodness of fit. Sign test, Wilcox test for unpaired test **(5)**

References:

1. Sokal R and Rahlf H (1995) 'Biometry: the principles and practice of Statistics for Biology research' *W H Freeman*.
2. Zar J (1998) 'Biostatistical analysis' *Prentice Hall*.
3. Rosner B (1995) 'Fundamentals of Biostatistics' *Duxbury Press*.
4. Daniel W (2005) ' Biostatistics: A Foundation for Analysis in Health Sciences' *Wiley*.
5. Aulay Mackenzie. (2007) 'Mathematics and Statistics for Life Scientists. Bios Instant Notes' *Taylor and Francis*.
6. Mathematics problems and study pack provided by the course instructor.

LIFE SCIENCE

M.Sc. **Course No.: SLSC803**

Course Title: Fundamentals of Immunology

Learning Objectives:

To help students:

1. Understand the concept of innate and adaptive immunity.
2. Describe the organization and the role of the various cells and organs of the immune system.
3. Understand the role of innate and adaptive immunity and the factors that contribute towards immunity.
4. Understand the disorders in immune response such as allergies, immunodeficiencies and modulation of the immune response during transplantation and for allergic responses.

Unit I: Introduction to the Immune System (15 Lectures)

1. Concept of Innate and Adaptive, Acquired and Passive Immunity **(1)**
2. Cells, tissues, organs of immunology.
   a. Innate Immunity: **(8)**
      i. Physicochemical barriers to infection, Antimicrobial peptides and proteins, Acute phase proteins, C-reactive proteins.
      ii. Complement System
      iii. Cellular players (Phagocytic cells, NK cells, Mast cells)
      iv. Pathogen Associated Molecular Patterns, Pattern Recognition Receptors, Signalling pathways
      v. Inflammation.
      vi. Mechanisms by pathogens to evade innate defences.
   b. Acquired Immunity: **(3)**
      i. Lymphoid Organs
      ii. APC, B Cell, T Cell
      iii. Antibodies (Structure, types and functions)
      iv. Bispecific antibodies, humanized antibodies, scFv
3. Immunological Methods: **(3)**
   a. Antigen antibody interaction and its applications: Agglutination, Precipitation, Immunodiffusion, Immunoelectrophoresis, ELISA, Radioimmunoassay, Immunohistochemistry, Flow Cytometry

Unit II: Antigen recognition and diversity of the immune receptors (15 Lectures)

1. Molecular basis of Antigen recognition and binding by Immunoglobulin **(1)**
2. T-Cell Receptor (TCR) and Antigen recognition by TCR **(2)**
3. MHC restriction, MHC I and II, Non-classical MHC, Generation of T-cell receptor ligand **(3)**
4. Genetic diversity of the Immune receptors **(7)**
   a. Primary Immunoglobulin gene rearrangement

b. Secondary diversification of antibody repertoire.
c. TCR gene rearrangement.
d. MHC locus and function.

5. Evolution of the adaptive immune response **(2)**

Unit III: Development of the Acquired Immune Response **(15 Lectures)**

1. Humoral Immune Response: **(4)**
   a. Development of B lymphocytes.
   b. B cell activation and antibody production.
      i. T-cell dependent and independent pathways.
   c. Distribution and functions of Immunoglobulin classes.
2. Cell-mediated immunity: **(5)**
   a. T cell development
      i. In the Thymus.
      ii. Positive and negative selection of T cells
      iii. In the peripheral lymphoid tissue and gamma-delta T cells in the gut.
   b. Priming of naive T cells and effector T cells
   c. T cell-mediated cytotoxicity
   d. Macrophage activation by TH1 cells
   e. Role of TH17 cells
3. Dynamics of the immune response to infection **(3)**
   a. Course of immune response to infection
   b. Immunological memory.
4. Mucosal Immune System: **(3)**
   a. Organization of the mucosal immune system
   b. Mucosal response to infections
   c. Regulation of the mucosal immune response

Unit IV: Immune system in health and disease **(15 Lectures)**

1. Tolerance, Allergy and Hypersensitivity: **(5)**
   a. Tolerance Mechanisms
      i. Central thymic and Post-thymic T-cell tolerance
      ii. B cell tolerance.
   b. Regulatory T cells: CD4, T_{REGS} and CD8 alpha-alpha cells
   c. Allergy: Effector mechanisms, IgE, mast cells and basophil mediated response.
   d. Hypersensitivity: Types and mechanisms
2. Autoimmunity and Immunodeficiencies **(4)**
   a. Cellular and Systemic Autoimmune disorders (Any 4 disorders)
      i. Mechanisms, Clinical manifestation and management.
   b. Deficiency in the innate and adaptive immune response (2 deficiencies each)
      i. Clinical manifestation and management.
3. Transplantation **(6)**
   a. Barriers to transplantation

b. Role of T cells in rejection
c. Clinical manifestations of rejection
d. Prevention of rejection.
e. Transplantation of kidney/liver/bone marrow

References:

1. Murphy K and Weaver C (2016) "Janeway's Immunobiology" *Garland Science*.
2. Kindt, Goldsby & Osborne (2008) "Kuby Immunology" *W. H. Freeman*.
3. Delves P.J., Martin S.J., Burton D.R. and Roitt M.I. (2017) "Roitt′s Essential Immunology" *Wiley Blackwell*.
4. Male D, Brostoff J, Roth D and Roitt I (2013) "Immunology" *Elsevier Saunders*.
5. Tizzard I (1995) "Immunology" *Saunders College Publishing*.
6. Kaufmann S. (2011) "The Immune Response to Infection" *ASM Press*.
7. Abbas A.K. (2003) "Cellular and Molecular Immunology" *Saunders*.
8. Reviews papers published recently on relevant topics.

LIFE SCIENCE

M.Sc. **Course No.: SLSC804**

Title: Microbial Diseases

Learning Objectives:

1. To understand host–parasite interactions by in-depth study of pathogenesis of various microbial parasites and immune response of the host to them
2. To study and understand infectious agents colonizing various organs and systems in human body.
3. To equip the students with a thorough knowledge of not only the clinical features and diagnosis of each of these diseases but also promote a clear understanding of the mechanisms for preventing the disease.

Number of lectures: 60

UNIT I **(15 lectures)**

1. Types of infectious diseases **(1)**
   a. Reservoirs of Infection
   b. Sites of entry, exit and transmission, types of transmission between humans, transmission from animals.
2. Pathogenesis of bacterial diseases **(5)**
   a. Reservoirs of bacterial pathogens
   b. Mechanisms of bacterial invasion growth and multiplication of pathogens
   c. Regulation of bacterial virulence factors
   d. Bacterial toxins
3. Pathogenesis of viral diseases **(3)**
   a. Entry, contact, and primary replication
   b. Viral spread and cell tropism
   c. Cell injury and clinical illness
   d. Recovery from infection
   e. Virus shedding
4. Interaction of the pathogen with the Innate and Adaptive Immune System **(6)**
   a. Immune response to bacterial, viral and fungal diseases.

UNIT II **(15 lectures)**

Detailed Study of the following infections including Etiology, Transmission, Pathogenesis, Clinical Manifestations, Lab. diagnosis, Prophylaxis, and Treatment.

1. Respiratory tract infections: **(7)**
   a. The common cold
   b. Influenza virus infection
   c. Pneumonia- Bacterial & Viral
2. Central nervous system infections: **(8)**
   a. Meningitis / Japanese Encephalitis
   b. Tetanus
   c. Polio
   d. CJD, Kuru

UNIT III **(15 lectures)**

1. Urinary tract infections: Pathogenesis, clinical features, complications, laboratory diagnosis, treatment, prevention. **(4)**
2. Gastrointestinal tract infections: **(6)**
   a. Diarrheal diseases caused by bacterial or viral infection
   b. Helicobacter pylori and gastric ulcer disease
   c. Round worm
   d. Typhoid
3. Sexually transmitted diseases: **(5)**
   a. Syphillis
   b. Human papilloma virus infection
   c. Human immunodeficiency virus

UNIT IV **(15 lectures)**

1. Vector borne infections: **(6)**
   a. Malaria
   b. Dengue
   c. Filariasis
2. Multi system zoonosis: **(4)**
   a. Anthrax
   b. Plague
3. Infections of skin and soft tissue: **(3)**
   a. Fungal infections of skin- Dermatophytosis / Candidiasis
   b. Bacterial infections of the skin
   c. Viral infections eg herpes simplex, chicken pox
4. Obstetric and perinatal infections **(2)**
   a. Congenital infections – Rubella virus

References:

1. Ewald PW (1994) "Evolution of Infectious Disease" *Oxford University Press*.
2. Scheld WM, Armstrong D and Hughes JM (1998) "Emerging Infections 1" *ASM Press*.
3. Scheld WM, Craig WA and Hughes JM (1998) "Emerging Infections 2" *ASM Press*.
4. Horsburgh, CR Jr and Nelson AM (1997) "Pathology of Emerging Infections" *ASM Press*.
5. Morse SS (1993) "Emerging Viruses" *Oxford University Press*.
6. Hantavirus Herper DR and Meyer AS (1999) "Of Mice, Men, and Microbes" *Academic Press*.
7. Klenk HD (1999) "Marburg and Ebola Viruses. Current Topics in Microbiology and Immunology" *Springer*.
8. Schlesinger RW (1977) "Dengue Viruses" Springer.
9. Tortora, Funk and Case (1998) "Microbiology: An Introduction" *Benjamin/ Cummings Publishing Company*.
10. Godkar, Praful B (1998) "Textbook of Medical Laboratory Technology Reprint" *Bhalani Publishing House*.

11. Goldsby, Richard, S. Kindt, Thomas J., Osborne, Barbara A(2000) "Immumnology" *W.H. Freeman and Company*.
12. Greenwood, David, Slack, Richard C.B., Peutherer, John F (1992) "Medical Microbiology: A Guide to Microbial Infections, Pathogenesis, Immunity, Laboratory Diagnosis and Control" *English Language Book Society*.
13. Isenberg, Henry D (1998) "Essential Procedures for Clinical Microbiology" *ASM Press*.
14. Janeway, Charles A., Jr. Travers, Paul (1994) "Immunobiology: The Immune System in Health and Disease" Blackwell Scientific Publications, Oxford.
15. Jawetz, Melnick, Adelberg, Edward (1998) "Medical Microbiology" *Prentice Hall International Inc*.
16. Kuby and Janice (1991) "Immunology" *W.H. Freeman and Company*.
17. Mackie T J., McCartney, J.E. (1989) "Practical Medical Microbiology" *Churchill Livingstone*.
18. Koneman, Elrner W. Allen, Stephen D., Janda, William M. Schreckenberge, Paul C (1997) "Color Atlas and Textbook of Diagnostic Microbiology" *Lippincott-Raven Publishers*.
19. Mukherjee, Kanai L. (1988) "Medical Laboratory Technology" *Tata MacGraw Hill Publishing Co. Ltd*.

Practicals Semester 8:

Course: SLSC8PR

Medical Microbiology and Immunology

1. GLP, media preparation, sterilization protocols, culturing methods (aerobic and anaerobic)
2. Preservation of micro-organisms: subculturing, glycerol stocks and lyophilization
3. Antibiotic sensitivity test -
   a. Minimum inhibitory concentration & minimum lethal concentration of an antibiotic (agar dilution/ broth dilution/ E-MIC strip agar diffusion
4. Isolation of antibiotic resistant mutants from soil/ sewage/UV exposure
5. Medical Microbiology
   a. Pure culture Study of Microorganisms on selective media
   b. Study of Biochemicals for identification of microorganisms: Oxidase, Catalase, Nitrate Reduction, IMViC, TSI, Urease, Sugar Fermentation, Lysine Decarboxylase, Phenylalanine deaminase, Coagulase, Haemolysin
   c. Identification of microorganism based on cultural characteristics on selective media and biochemical characteristics.
   d. AST
6. Agglutination Reactions:
   a. Study of Blood groups: Forward and reverse typing
   b. Isohemagglutinin titre in blood
   c. Quantitative Widal Test
7. Precipitation Reaction:
   a. Single (Radial) immunodiffusion
   b. Double immunodiffusion (Ouchterlony)
8. Separation of Mononuclear cells (lymphocytes) using a gradient and the determination of viable count of the same.
9. Purification of IgG from serum.
10. Innate Immunity: Testing the effects of saliva, tears, lysozyme on Staphylococcus, Streptococcus.
11. Bioassay (microbiological assay) for determination of antibiotics and or vitamin(Vit B12)
12. Use of MS Excel and SPSS for Plotting Graphs and to solve problems

Template of Theory Question paper
M.Sc. Life Science
801, 802, 803, 804

CIA I – 20 marks, 45 mins.

Objectives/Short questions

CIA II – 20 marks, 45 mins.

Test/ Survey/ Assignment/ Presentation/ Poster/ Essay/ Review

End Semester exam – 60 marks, 2 hours

Choice is internal- within a unit and could be between 50% to 100%

M.Sc. Life Science
Practical Evaluation
Course: SLSC8PR

CIA & End Semester Practical Exam	**Total marks: 200**
CIA	80 marks
ESE	120 marks

For CIA: (20 marks journal + 60 marks experiments/viva etc)

St. Xavier's College – Autonomous Mumbai

Syllabus
For 9th Semester Courses in
M.Sc. Life Science
(June 2018 onwards)

Contents:

LIFE SCIENCE

M.Sc. **Course No.: SLSC901**

Title: Clinical Microbiology and Public Health

Learning Objectives:
On completion of the course, the student must be able to

1. Understand the principles of the diagnostic methods used in Clinical Microbiology.
2. This course provides an elaborate overview of all the possible mechanisms of controlling microbial growth and disease.
3. This course also aims to allow the students to have an insight into epidemiology of infectious diseases, analysing different public health measures that goes in to understanding the spread of the disease and its eradication.

Number of lectures: 60

UNIT I: Diagnostic methods in Clinical Microbiology (15 lectures)

1. Common staining procedures in Clinical Microbiology: Ziel Neelson Stain Spore stain **(2)**

2. Invitro culture principles and applications: **(5)**
   Culture media for inoculation of specimens, recommended procedure for inoculation of specimens, tests for distinguishing Gram positive organisms, tests for distinguishing Gram negative bacteria.

3. Serological diagnosis - Western blot, ELISA- types and applications **(3)**
4. Developmemts in diagnostic techniques **(5)**
   a. Immunohistologic techniques
   b. Molecular biology techniques
   c. In situ hybridization
   d. PCR
   e. Microarrays.

UNIT II: Control and Prevention of Microbial Growth (15 lectures)

1. **Antimicrobials:** (two examples of each) **(5)**
   a. Antibacterial agents – chemistry, category, mode of action, mechanism of resistance
   b. and side effects of Cell wall inhibitors, inhibitors of protein synthesis, inhibitors of
   c. membrane function, DNA inhibitors, inhibitors with other modes of action, antituberculous agents
   d. Antifungal antimicrobics
   e. Antiprotozoan antimicrobics
   f. Antiviral agents
   g. Antiparasitic agents

2. **Antibiotic Use and Misuse:** Mechanisms of Resistance: Transfer and Expression
   a. Natural Resistance **(4)**
   b. Acquired Resistance eg. Tuberculosis

c. Physiologic Mechanisms of Drug Resistance

3. **Vaccines** **(6)**

a. Aims of Vaccination, Requirements of a good vaccine. Active and Passive
b. Immunisation
c. Designing vaccines for active immunization – Live, Attenuated vaccines, "Inactivated" or "killed" vaccines, Subunit vaccines, Conjugate vaccines, DNA vaccines.
d. Current vaccine practices- Recombinant vector vaccines (any two)
e. New and experimental vaccines (any two)
f. Monoclonal Antibodies
g. Phage display libraries.

UNIT III: Epidemiology and Public Health **(15 lectures)**

1. Definition, scope and uses of epidemiology **(1)**
2. Epidemiology and Public health – Cause of disease, Natural history, health status of populations, evaluating interventions **(2)**
3. Achievements in epidemiology **(4)**
   a. Small pox
   b. Iodine deficiency diseases
   c. HIV/ AIDS
   d. SARS
4. Measuring health and disease **(3)**
5. Public health surveillance: purpose and characteristics , identifying health **(5)**
6. problems for surveillance, collecting data for surveillance, analyzing and interpreting
7. data, disseminating data and interpretation, evaluating and improving surveillance

UNIT IV: Emerging Infectious Diseases **(15 lectures)**

1. Emerging disease patterns
2. Determinants of Emerging disease: **(2)**
   a. Host- change in demographics
   b. Pathogen- origins, adaptation, change (genotypic and phenotypic)
   c. Environment- climatologic, geographic, topographic, ecologic.
3. Prevention goals (CDC, OIE, USDA: APHIS and others). **(1)**
4. Emerging viral diseases **(6)**
   a. Severe Acute Respiratory Syndrome
   b. H1N1 Influenza
   c. Avian Influenza
5. Emerging Bacterial Infections **(4)**
   a. Multi-drug resistant tuberculosis
   b. MRSA
   c. E. coli 0157:H7
6. Emerging Zoonotic Bacterial Pathogens **(2)**
   Helicobacter species

References:

1. Ewald PW (1994) "Evolution of Infectious Disease" *Oxford University Press*.
2. Scheld WM, Armstrong D and Hughes JM (1998) "Emerging Infections 1" *ASM Press*.
3. Scheld WM, Craig WA and Hughes JM (1998) "Emerging Infections 2" *ASM Press*.
4. Horsburgh, CR Jr and Nelson AM (1997) "Pathology of Emerging Infections" *ASM Press*.
5. Morse SS (1993) "Emerging Viruses" *Oxford University Press*.
6. Hantavirus Herper DR and Meyer AS (1999) "Of Mice, Men, and Microbes" *Academic Press*.
7. Klenk HD (1999) "Marburg and Ebola Viruses. Current Topics in Microbiology and Immunology" *Springer*.
8. Schlesinger RW (1977) "Dengue Viruses" Springer.
9. Tortora, Funk and Case (1998) "Microbiology: An Introduction" *Benjamin/ Cummings Publishing Company*.
10. Godkar, Praful B (1998) "Textbook of Medical Laboratory Technology Reprint" *Bhalani Publishing House*.
11. Goldsby, Richard, S. Kindt, Thomas J., Osborne, Barbara A(2000) "Immumnology" *W.H. Freeman and Company*.
12. Greenwood, David, Slack, Richard C.B., Peutherer, John F (1992) "Medical Microbiology: A Guide to Microbial Infections, Pathogenesis, Immunity, Laboratory Diagnosis and Control" *English Language Book Society*.
13. Isenberg, Henry D (1998) "Essential Procedures for Clinical Microbiology" *ASM Press*.
14. Janeway, Charles A., Jr. Travers, Paul (1994) "Immunobiology: The Immune System in Health and Disease" Blackwell Scientific Publications, Oxford.
15. Jawetz, Melnick, Adelberg, Edward (1998) "Medical Microbiology" *Prentice Hall International Inc*.
16. Kuby and Janice (1991) "Immunology" *W.H. Freeman and Company*.
17. Mackie T J., McCartney, J.E. (1989) "Practical Medical Microbiology" *Churchill Livingstone*.
18. Koneman, Elrner W. Allen, Stephen D., Janda, William M. Schreckenberge, Paul C (1997) "Color Atlas and Textbook of Diagnostic Microbiology" *Lippincott-Raven Publishers*.
19. Mukherjee, Kanai L. (1988) "Medical Laboratory Technology" *Tata MacGraw Hill Publishing Co. Ltd*.

LIFE SCIENCE

M.Sc. **Course No.: SLSC902**

Title: Human Physiology II

Learning Objectives:
The course aims at:
1. Imparting knowledge and understanding of the structural organization of the human body and its functional segregation into various systems, and understand the physiological interdependence of various systems.
2. Introducing the students to the physiological and cellular mechanisms underlying disorders of various organ systems.

Number of lectures: 60

UNIT I **(15 lectures)**

Nervous system:

1. Neurons and Glia – structural and functional features. **(2)**
2. Nerve Impulse transmission; Channels and Transporters. **(3)**
3. Synapse: Types of synapses, Synaptic Transmission, Synaptic Potentials, Synaptic Plasticity and long-term potentiation. **(4)**
4. Structural and functional organization of the Nervous system: CNS and PNS **(2)**
5. Understanding brain anatomy & function, Anomalous examples of behavior, Brain imaging techniques – CT, PET, MRI **(2)**
6. The Autonomic Nervous system. **(1)**
7. Organization: The sensorimotor pathways **(1)**

UNIT II **(15 lectures)**

1. Neurotransmitters: Acetylcholine, Catecholamines (Norepinephrine, Dopamine), Glutamate, GABA: mode of actions, receptor types and functional diversity. **(5)**
2. Neuronal signal transduction process and related disorders:
   a. Phototransduction: Structural organization of the retina, photoreceptors, mechanism of phototransduction
   b. Chemotransduction: olfaction and gustation: receptors, structure and mechanism of transduction
   c. Mechanotransduction: Auditory system: cochlea and organ of Corti, receptors and mechanism of transduction, auditory pathway **(6)**
3. Neurological disorders: Parkinsons's, Alzheimer's, Schizophrenia, Bipolar disorder **(4)**

UNIT III **(15 lectures)**

Endocrine system:

1. Concept of cell signaling: Endocrine, autocrine, paracrine. Chemical nature of hormones, general mode of action on target cells. **(2)**
2. The Hypothalamus and Pituitary – Structural and Functional relationship; Hormones of the Anterior and Posterior Pituitary; Growth hormone: function and disorders **(3)**
3. Target Tissues of the Tropins and their Hormones: Thyroid (Thyroid disorders), Parathyroid, Adrenals, Pancreas (insulin, glucagon; Disorder: Diabetes mellitus). **(7)**

4. Homeostasis and Hormonal regulation –Water, electrolytes and acid-base balance; Thermoregulation; Blood volume control. **(3)**

UNIT IV **(15 lectures)**

A) Reproductive System:

1. Differentiation of sex and development of male and female reproductive systems; Oogenesis and Spermatogenesis. **(2)**
2. Overview of the reproductive systems; The Hypothalamus-Pituitary-Gonadal axis; Cellular and molecular interactions in ovary and testis; Menstrual Cycle – Cyclic changes at Ovarian and Uterine level. **(3)**
3. Hormonal Regulation of Fertilization and Implantation. **(2)**
4. Hormonal Changes during Pregnancy, Parturition and Lactation. **(2)**

B) Male and Female Fertility Management:

1. Common causes of male and female infertility – anatomical, hormonal, genetic. **(1)**
2. Disorders of Folliculogenesis and ovulation: Polycystic Ovary Syndrome; Abnormal spermatogenesis. **(2)**
3. Assisted Reproductive Technologies (ARTs) – IVF-ET, ICSI, GIFT, ZIFT; Preimplantation Genetic Diagnosis; Researchable areas and Ethical issues in ART **(1)**
4. Contraception and Family Planning **(1)**
5. Menopause and Hormone Replacement Therapy; Synthetic Estrogens and Phytoestrogens. **(1)**

References

1. Guyton AC and Hall JE (2006) "Textbook of Medical Physiology" *Elsevier Saunders*.
2. Saladin K (2003) "Anatomy & Physiology: The Unity of Form and Function" *The McGraw−Hill Companies*.
3. Seeley R, Stephens T and Tate P "Anatomy and Physiology" *The McGraw−Hill Companies*.
4. Fox S (2003) "Human Physiology" *The McGraw−Hill Companies*.
5. Rhodes R and Tanner G (2003) "Medical Physiology" *Lippincott Williams & Wilkins*.

LIFE SCIENCE

M.Sc. **Course No.: SLSC903**

Title: Molecular Biology and Recombinant DNA Technology

Learning Objectives:
This course aims to provide a molecular understanding of the information processing pathways in the cell that lead to the expression of the genetic information in DNA.

1. To understand the molecular processes of DNA replication, transcription, and translation, and how they are managed in cells.
2. To understand protein and nucleic acid structure and function, and the relationship between them, both in vitro and in vivo.
3. To understand the principles of gene expression and its regulation in prokaryotes and eukaryotes.
4. To understand the principles and application of gene cloning in industry and medicine

Number of lectures: 60

UNIT I **(15 lectures)**

1. DNA topology: Supercoiling, denaturation and renaturation kinetics, C-value paradox **(2)**
2. DNA replication: DNA replication in E.coli (guided self-study), Eukaryotic DNA replication (guided self study), and Viral DNA replication (Rolling circle model) **(3)**
3. DNA damage and repair: UV/chemicals, Repair systems (mismatch, nucleotide excision, base excision, recombination lesion, photoreactivation, SOS **(4)**
4. DNA recombination: homologous, and site-specific **(4)**
5. Mobile Genetic Elements: Prokaryotic and eukaryoptic Transposons one eg each. **(2)**

UNIT II **(15 lectures)**

1. Concept of a gene (self study) **(2)**
2. Transcription: prokaryotic and eukaryotic transcription **(3)**
3. Post-transcriptional processing: capping, splicing, polyA tail addition of mRNA; self splicing. **(5)**
4. Genetic code: universality, mitochondrial codon usage, wobble hypothesis (self study) **(1)**
5. Translation: protein synthesis in prokaryotes and eukaryotes **(3)**
6. Post-translational modifications (self study) **(1)**

UNIT III **(15 lectures)**

1. Protein-nucleic acid interactions: eg transcription factors; types of DNA binding motifs, interactions with DNA, gel-mobility shift assay, chromatin immunoprecipitation **(6)**
2. Regulation of gene expression in prokaryotes: **(1)**

a. The Lactose Operon in *E. coli* (self study)
b. The Tryptophan/ arabinose Operon in *E. coli* (guided self study)

3. Regulation of gene expression in eukaryotes: **(8)**

a. Gene rearrangement in immunoglobulin genes
b. Maternal gene expression in drosophila development

UNIT IV **(15 lectures)**

1. Restriction endonucleases: Type II R.E and its mechanism of cleavage (self study **(1)**
2. Vectors: plasmid, phage, transcription vectors, expression vectors (pGLO, lacZ),eukaryotic vectors **(1)**
3. Selection methods: antibiotic resistance, lacZ, GFP (self study) **(1)**
4. Cloning of genes: using genomic DNA libraries, cDNA cloning, PCR cloning **(1)**
5. Screening of cloned genes: nucleic acid hybridization, immunochemical method, Southern blots **(1)**
6. DNA sequencing: **(4)**
   Chain termination method, pyrosequencing, whole genome sequencing, contig mapping
7. Applications of gene cloning: **(6)**
   RFLPs, DNA fingerprinting, production of useful molecules, transgenic animals, transgenic plants, whole animal cloning, gene therapy, knock outs, knock down, knock-ins.

References:

1. Lodish H, Berk A, Kaiser CA, Krieger M, Bretscher A. (2016) 'Molecular Cell Biology' *W H Freeman*.
2. Watson JD, Baker TA, Bell SP, Gann A, Levine M, Losick R. (2014) Molecular Biology of the Gene. 7th Ed. *Pearson*.
3. Alberts B, Johnson A, Lewis J, Raff M, Roberts K, Walter P. (2014) Molecular Biology of the Cell. 7th Ed. *Garland Science.*
4. Pierce BA. (2013) Genetics – A Conceptual Approach. 5th Ed. *Barnes and Noble*.
5. Hartl DL, Ruvolo M. (2011) Genetics – Analysis of Genes & Genomes. 8th Student Ed. *Jones and Bartlett*.
6. Snustad DP, Simmons MJ. (2009) Principles of Genetics. 5th International Student Ed. *Wiley Publishing Ltd*.
7. Wessler SR, Lewontin RC, Gelbart WM, Suzuki DT, Miller JH (2004) Introduction to Genetic analysis. 8th Ed. *WH Freeman & Company*.
8. Atherly AG, Girton JR, McDonald JF. (1999) The Science of Genetics. *Daine Pub. Co*.
9. Weaver RF, Hedrik PW. (1997) Genetics. 3rd Ed. *Barnes and Noble.*

LIFE SCIENCE

M.Sc. **Course No.: SLSC904**

Title: Analytical Techniques

Learning Objectives:
On completion of the course, the student must be able to:

1. To be aware of the various approached used in the study of biological samples.
2. To understand the principles of separation and investigation applied to analysis of biological samples.
3. To identify current trends in calibrations and certifications association with instrumentation techniques (to be covered in practicals).

Number of lectures: 60

UNIT I: Methods based on separation **(15 lectures)**

A. Centrifugation **(5)**

1. Basic principles; Theory (RCF, Sedimentation coefficient, etc)
2. Types of centrifuge - microcentrifuge, clinical, high speed and ultracentrifuges
3. Types of centrifugation: Preparative centrifugation; Analytical centrifugation. [Differential & density gradient centrifugation]

4. Applications: Isolation of cell components , Determination of molecular weight by Sedimentation velocity & sedimentation equilibrium methods

B. Chromatography techniques**:**

Partition, Thin Layer, Gas, Molecular Exclusion, Ion-exchange, Affinity, Reverse phase, HPLC and FPLC

UNIT II: Methods based on electromagnetic spectrum **(15 lectures)**

1. Electromagnetic spectrum and Interaction of radiation with matter. (guided study) **(1)**

2. Measurement of transmission and absorbance- (Beer's Law derivation). **(2)**
3. UV and Visible spectrophotometry. **(2)**
4. IR spectroscopy. **(1)**
5. Atomic absorption and Atomic emission spectroscopy. **(3)**
6. Introduction to : (Principle and application in biology) **(6)**
   i. NMR spectroscopy.
   ii. ORD and CD spectroscopy.
   iii. X-ray Diffraction
   iv. Fluorescence spectroscopy

UNIT III: Methods based on electrophoresis/ fragmentation techniques/ thermal analysis etc. (15 lectures)

1. Electrophoresis: Discontinuous, Iso-electric focusing, 2D, Capillary electrophoresis, Pulsed field electrophoresis **(6)**
2. Methods based on fragmentation and hyphenated techniques – **(4)**
   An introduction to:
   a. Mass spectrometry
   b. LC-MS.
3. Methods based on heat of interaction/ thermal analysis/binding constants **(5)**
   a. Isothermal Calorimetry (ITC)
   b. Surface Plasmon Resonance Spectroscopy (SPR)

UNIT IV: Investigative methods based on Microscopy, Radioactivity (15 lectures)

1. Microscopy (Self-study) **(8)**
   a. Principles of light microscopy
   b. Phase contrast microscopy
   c. Fluorescence microscopy – Epifluorescence , Confocal
   d. TEM, SEM
   e. Atomic force microscopy/SFM
2. Methods based on Radioactivity: **(7)**
   a. Radioactive rays and their properties.
   b. Measurement of Radioactivity.
3. Detection of Radioactivity, GM counters and Scintillating counters
4. Application of radioactivity in biology, RIA.

References:

1. Skoog, D.A., Holler, F.J., Crouch S.R. (2018) "Principles of Instrumental Analysis" *Cengage Learning*.
2. Sheehan, D. (2010) "Physical Biochemistry: Principles and Applications" Wiley-Blackwel.
3. Manz, A., Dittrich, P.S., Pamme, N., Iossifidis, D. (2015) "Bioanalytical Chemistry" *Imperial College Press*.
4. Schalkhammer, Thomas G.M. (2002) "Analytical Biochemistry" *Springer (India) Private Limited*
5. Cooper, T.G. (2009) "The Tools of Biochemistry" *Wiley*.
6. Spector, David L. & Goldman, R.D. (2006) "Basic Methods in Microscopy: Protocols And Concepts From Cells: A Laboratory Manual" Cold Spring Harbor Laboratory Press.
7. Pawley, James B. (2006) "Handbook of Biological Confocal Microscopy" *Springer Science Plus Business Media*.
8. Chandler, Douglas E. & Roberson, Robert W. (2009) "Bioimaging: Current Concepts in Light and Electron Microscopy" *Jones and Bartlett Publishers*.
9. Wilson, K. & Walker, J. (2013) "Principles and Techniques of Biochemistry and Molecular Biology" *Cambridge University Press.*

Practical:

Course SLSC9PR

Cell Culture Techniques, Molecular Biology, Physiology and Medical Laboratory Diagnostics

1. Preparation of single cell suspension and viability count (dye exclusion/fluorescence)
2. Setting up Primary fibroblast cultures of chick embryo/ chicken liver
3. Trypsinization of monolayer and subculturing
4. MTT assay for cell viability
5. Cryopreservation of cultured cells
6. Preparation of paraffin blocks and tissue sectioning (microtomy) as a demonstration experiment
7. Histological studies of vertebrate tissue using HE staining (mouse/chick)
8. Isolation of DNA from *E. coli*.
    a. Determination of purity of DNA using UV absorbance 260:280
    b. Separation of DNA using agarose gel electrophoresis.
9. Isolation of plasmid DNA by the Alkali lysis method.
10. PCR amplification of a desired gene
11. RE digestion and insertion of DNA
12. Preparation of competent cells and transformation.
13. Selection and Screening of transformed cells.
14. Expression of recombinant protein-induced v/s un-induced state
15. Construction of a restriction map of plasmid DNA
16. Cognitive function tests (COG LAB): Tests for Attention, working and Memory span.
17. Neuronal enzyme assays: AChE/Na-K ATPase
18. Basic Hematology
    a. CBC, platelet count, PCV, ESR.
    b. Bleeding time, Clotting time.
19. Biochemistry of body fluids
    a. Serum glucose by GOD-POD method and GTT
    b. SGPT, SGOT and Bilirubin
    c. Total protein and albumin
    d. Serum cholesterol, Lipid profile: Triglycerides, LDL, HDL
20. Visit to Industry/ Research Institute/ IVF lab. (Optional)

Template of Theory Question paper
M.Sc. LIFE SCIENCE
Courses: 901, 902, 903, 904

CIA I – 20 marks, 45 mins.
Objectives/Short questions

CIA II – 20 marks, 45 mins.
Test/ Survey/ Assignment/ Presentation/ Poster/ Essay/ Review

End Semester exam – 60 marks, 2 hours
Choice is internal- within a unit and could be between 50% to 100%

M.Sc. Life Science
Practical Evaluation
Course: SLSC9PR

CIA & End Semester Practical Exam	**Total marks: 200**
CIA	80 marks
ESE	120 marks

For CIA: (20 marks journal + 60 marks experiments/viva etc)

St. Xavier's College – Autonomous Mumbai

Syllabus
For 10th Semester Courses in
LIFE SCIENCE

(June 2018 onwards)

Contents:

LIFE SCIENCE

M.Sc. **Course No.: SLSC1001**

Title: Human Genetics

Learning Objectives:

On completion of the course, the student must:

1. Understand the concepts of human genetics, in particular, the general features and organization of the human genome, conventional and molecular cytogenetics, chromosomal abnormalities and the human genome project.
2. Comprehend mitochondrial genome organization and its relevance to human evolution.

Number of lectures: 60

UNIT I **(15 lectures)**

1. History of Human Chromosome Research - Denver Conference (1940) -
2. Chicago Conference (1966) - Paris Conference (1971) -Nomenclature of Human Chromosome **(2)**
3. Nuclear genome: General features and organization of Human Genome **(3)**
4. Unique sequences and families of reiterated sequences **(2)**
5. Extragenic repeated sequences and transposable elements, LINES and SINES **(3)**
6. Gene families: Clustered and Dispersive : eg histone gene clusters, haemoglobin gene clusters **(2)**
7. Pseudogenes **(1)**
8. Human genome and the last five million years. **(2)**

UNIT II **(15 lectures)**

1. Identification of Human diploid chromosome –

a. peripheral blood cultures

b. banding techniques - G-band; Q-band C-band R-band

c. Identification of 23 pairs of Human chromosomes by band position, Chromosomal shape, karyotype, ideogram.

d. An International System for Human Cytogenetic Nomenclature (ISCN) **(4)**

2. Molecular cytogenetics

a. Fluorescent in situ hybridization (FISH)- principle and technique chromosome painting and molecular karyotyping

b. Comparative genome hybridization (CGH). **(3)**

3. Perinatal diagnosis & counselling **(3)**

a. Prenatal diagnosis**:** Chorionic villi samplingFoetoscopy, Ultrascopy, Amniocentesis

b. Postnatal diagnosis

c. Pre-Implantation genetic diagnosis

d. Genetic Counseling and carrier detection

4. Chromosomal syndromes**:** Autosomal syndromes, Sex chromosomal syndromes, Structural chromosomal syndromes (one example each). **(2)**
5. Genomic imprinting – Mechanism of genomic imprinting, Angelman syndrome/ Prader-Willi syndrome **(3)**

UNIT III **(15 lectures)**

1. Mitochondrial genome organization. **(1)**
2. Human Mitochondrial Mapping – Human Mitochondrial genome **(3)**
3. Mitochondrial DNA & Aging in Human – Mechanism of age-related increase in mtDNA damage, decline of oxydative phosphorylation capacity with age, late onset degenerative diseases. **(4)**
4. Transcription and translation of mt genes. (3)
5. mtDNA & human disease **(2)**
6. Tracing Human History through Mitochondrial DNA –To study Human evolution using mtDNA. **(2)**

UNIT IV **(15 lectures)**

1. Goals of the project, major scientific strategies & approaches used in HGP. **(1)**
2. How Human genome was mapped and sequenced: physical mapping, genetic mapping. **(6)**
3. Technologies used–RFLP, microsatellite markers, STS, EST, DNA microarray **(6)**
4. HGP & its impact. **(2)**

References:

1. Griffiths AJF, Wessler SR, Carroll SB and Doebley J (2015) "Introduction to Genetic Analysis" *W.H.Freeman Publishers*.
2. Russell PJ (2009) "iGenetics – A Molecular Approach" *Benjamin Cummings Publication*.
3. Lewis R (2005) "Human Genetics- Concepts and Application" *McGraw Hill Pub*.
4. John Reid & Tom Strachan (2011) "Human Molecular Genetics" *Garland Science, Taylor and Francis Group*.
5. Daniel L. Hartl and Maryellen Ruvolo (2012) "Genetics – Analysis of Genes and Genomes" *Jones and Bartlett India Pvt. Ltd*.
6. Peter Turnpenny and Sian Ellard (2013) "Emery's Elements of Medical Genetics" *Churchill Livingston Pub*.

LIFE SCIENCE

M.Sc. **Course No.: SLSC1002**

Title: Pharmacology and Nutraceuticals

Learning Objectives:

On completion of the course, the student must be able to:

1. Understand the basis of drug action (pharmacodynamics)
2. Describe the various strategies used in pharmacotherapy
3. Explain the concept drug metabolism (pharmacokinetics)
4. Discuss the influence of genetic constitution of an individual on drug response
5. Summarize the principles of clinical pharmacology
6. Explain the tenets in the emerging field of nutraceuticals

Number of lectures: 60

UNIT I: General Principles of Pharmacology (15 lectures)

1. Introduction to Pharmacology **(3)**
   a. Basic terminology
   b. Sources of drugs and nomenclature of drugs
   c. Routes of drug administration
2. Drug-receptor interactions (pharmacodynamics) **(4)**
   a. Classification of drug receptors
   b. Principles of drug action – quantal and graded dose-response curves
   c. Theories of drug-receptor interaction – occupancy theory (agonist / antagonist), modified occupancy theory (agonist), allosteric theory (partial agonist)
3. Factors modifying drug-receptor interactions
4. Drug Enzyme interactions (pharmcodynamics) **(3)**
   a. Classification of enzymes inhibitors
   b. Examples of drugs that are enzymes inhibitors (competitive, non-competitive, uncompetititive and irreversible)
5. Drug Metabolism **(5)**
   a. Definition, Need, Consequences
   b. Organs involved in DM, Enzymes involved
   c. Phase-I and phase-II transformations
   d. Concept of hard and soft drugs

UNIT II: Pharmacotherapy (15 lectures)

1. Strategies in drug therapy (based on **any one** prototype drug for each) **(5)**
   a. Central nervous system: antidepressants
   b. Respiratory system: pharmacotherapy of bronchial asthma
   c. GI system: antacids
   d. Cardiovascular system: beta adrenergic blockers
   e. Endocrine system: thyroid modulators
2. Drug delivery systems in pharmacotherapy **(4)**
   a. Modified or Controlled drug release systems
   b. Targeted delivery system: liposomes
   c. Nanoparticular systems: coated-nanoparticles, nanogels

3. Pharmacogenomics **(6)**
   a. Genomics of PD profile (receptor-allelic variation)
   b. Genomic of PK profile (*CYP*-allelic variation)
   c. Database resources in pharmacogenomics
   d. Methods in pharmacogenomics: association- & expression-based cheminformatics

UNIT III: Clinical pharmacology **(15 lectures)**

1. General pathway of drug discovery/development **(3)**
2. Pharmacological screening models for therapeutic areas (one case study) **(4)**
3. Clinical trials – rationale and phases **(4)**
4. Ethical and regulatory aspects of clinical trials in India **(4)**

UNIT IV: Nutraceuticals **(15 lectures)**

1. Concept of nutraceuticals and functional foods **(1)**
2. Classification of nutraceuticals – chemical and biochemical basis **(1)**
3. Sources and uses of nutraceuticals **(4)**
4. Disease-management using nutraceuticals (case studies) **(4)**
5. Monitoring of multi-component phytopharmaceuticals **(3)**
6. Safety issues regarding nutraceutical consumption (case studies) **(2)**

References

1. Ed. Hardman JG, Limbird LE (2001) "Goodman Gillman's The Pharmacological Basis of Therapeutics" *McGraw Hill Press*.
2. Ed. Shargel L. (1999) "Applied Biopharmaceutics and Pharmacokinetics" *Prentice-Hall International*.
3. Ghosh MN (1984) "Fundamentals of Experimental Pharmacology". *Scientific Book Agency*.
4. Forman JC, Johansen TJ (1996) "Textbook of Receptor Pharmacology" *CRC Press*.
5. Vogel HG & Vogel WH (1997) "Drug Discovery and Evaluation –Pharmacological Assays" *Springer*.
6. Chadwick R., Henson S., Mosley B., Hurst G.W. (2003) "Methods of Analysis for Functional Foods and Nutraceuticals" *Springer.*
7. Pharmacology-related journals from PubMedCentral (refer study pack for papers)

LIFE SCIENCE

M.Sc. **Course No.: SLSC1003**

Title: Laboratory Management and Routine Diagnostics

Learning Objectives:

The course aims to:

1. Introduce students to basic clinical laboratory setup as well as GLP and accreditations
2. Help students understand routine analysis of biological fluids and specific organ function tests, and their clinical significance
3. Introduce students to non invasive methods for diagnosis

Number of Lectures: 60

UNIT I **(15 lectures)**

1. Introduction to Clinical Laboratory **(6)**
a. Standard Clinical Laboratory set up
b. Decontamination and Disinfection.
c. Sterilization techniques
d. Hazard analysis, Safety Data Sheets, and First Aid Kit.
2. Collection, transport and examination of specimen. **(2)**
3. Total Quality Management: **(7)**
a. Quality Control mechanisms, (Internal and External)
b. Preparation of lab report and cataloguing.
c. Basic principles of accreditation of labs, (ISO and NABL).
d. GLP

UNIT II **(15 lectures)**

1. Routine Blood tests **(2)**
a. Complete Blood Count and Hematological Indices.
b. PCV, ESR
c. Reticulocyte count
2. Variants of hemoglobin and Abnormal hemoglobin identification. **(2)**
3. Erythrocyte disorders (at least two) **(3)**
4. Hemostasis, coagulation and routine coagulation tests **(7)**
a. Mechanism of coagulation
b. Congenital deficiencies of hemostatic factors (self study)
c. Routine coagulation tests
d. Bleeding disorders
e. Bleeding time, clotting time, prothrombin time, Partial Thromboplastin time and Activated PTT
5. Basic principles of blood banking. **(1)**

UNIT III **(15 lectures)**

1. Cardiac profile tests
2. Liver function tests
3. Kidney function tests

4. Thyroid function tests
5. Pulmonary function tests

UNIT IV **(15 lectures)**

1. Routine analysis of body fluids; urine, sputum, CSF, semen, cavity fluids: pericardial, peritoneal and synovial. **(7)**
2. Parasitology and routine examination of feces.
3. Histopathological approaches to diagnosis **(4)**

a. Fixation and fixative tissue processing
b. Immunostaining
c. PAP smear.

4. Non-invasive imaging techniques-MRI, CT scan, PET scan, fdg-PET **(4)**

References:

1. Godkar PB (2005) "Textbook of Medical Laboratory Technology" *Tata McGraw Hill*
2. Raphael SS (1976) "Lynch's Medical Laboratory Technology" *WB Saunders Company.*
3. Todd, Sanford and Davidsohn (2016) "Clinical Diagnosis and Management" *WB Saunders Company.*
4. Patel AH (1994) "A Manual of Medical Laboratory Technology" *Universal Book Corp.*

LIFE SCIENCE

M.Sc. **Course No.: SLSC1004**

Title: Applied Biology

Learning Objectives:

1. Understanding the genetic basis of cancer
2. To identify the various factors that can transform a cell to become cancerous
3. Elucidate the underlying principles of how cancer cells bypass the normal controls
4. Understanding how cancer can be tackled by targeting the characteristics specific to the cancerous cells.
5. Provide the student with information of basic principles, recent developments and scope of some contemporary areas of stem cell research in biology research and medicine.

Number of lectures: 60

UNIT I: Nanotechnology **(15 lectures)**

1. Introduction to Nanoscience and Nanotechnology
   A. History, Definitions, Dimensions – The 'Nano' Scale **(1)**
   B. Overview of different nanomaterials available **(4)**
   Carbon based materials – CNT, Fullerenes; Quantum dots; Self-assembled nanomaterials; Core-shell particles [Metals and alloys, Semiconductors, Ceramic and glassy materials, Composites, Zeolites, Porous silicon, Aerogels, Hydrogels]
   C. Unique properties of nanoscale material **(2)**
   Importance of surface, particle size and particle orientation
   Mechanical, Structural, Optical and Magnetic properties, Melting, Electrical conductivity
   D. Synthesis and fabrication of nanomaterials (Guided self-study) **(1)**
   Physical, Chemical, Biological (Microbes, Plant extracts, Protein and DNA)
   E. Tools of Nanoscience (Self study – covered in M.LSC.2.04 Analytical Techniques) **(1)**
   Electron microscopy, SEM, TEM

2. Applications of Nanotechnology:
   A. Biomedical - Imaging and diagnostics, Cancer detection, Drug delivery, Tissue regeneration **(3)**
   B. Environmental - Water, Air and Soil – Monitoring and mitigation **(1)**
   C. Energy (Solar cells, fuel cells, batteries) **(1)**

UNIT II: Stem Cell Biology **(15 lectures)**

1. The Evolving Concept of a Stem Cell : Definitions, Criteria and Standards **(1)**
2. Embryonic Stem Cells : An overview of Embryogenesis (Fertilization to Gastrulation – Guided Self Study), Molecular pathways of Pluripotency (NOTCH, BMP, Sonic Hedgehog pathways), Human ES cells and Directed Differentiation, Cord Blood Stem Cells. **(5)**
3. Adult Stem Cells (W.R.T. Hematopoeitic and Neural Stem Cells): Stem Cell Niche, Tissue-specific Stem Cells, Induced Pluripotent Stem Cells (iPS),

Transdifferentiation **(5)**

4. Stem Cell Research:

a) Ethical and Religious issues and Regulatory considerations **(1)**
b) Potential applications and Future Challenges : i) Cell Replacement Therapies, Tissue Engineering, Stem Cell Gene Therapy (Translational Stem Cell Medicine) **(3)**

UNIT III: Cancer biology - 1 **(15 lectures)**

1. Introduction & The Hallmarks of Cancer and cancer assays and models **(3)**
2. Cell cycle control **(1)**
3. Pathways that contribute to tumour progression **(11)**
    a. Rb pathway
    b. Signal transduction
    c. BCR-Abl
    d. Myc
    e. Checkpoint signalling

UNIT IV: Cancer Biology – 2 **(15 lectures)**

1. Pathways contributing to tumour progression **(5)**
    a. p53
    b. Telomerase
    c. BRCA1
    d. Mis-match repair
    e. APC and Wnt signalling
2. Tumour Immunology **(2)**
3. Angiogenesis **(2)**
4. Epigenetics and Cancer **(2)**
5. Cancer stem cells **(2)**
6. Metastasis **(2)**

* including but not limited to

References:

1. Hanahan D and Weinberg R (2011) 'Hallmarks of Cancer: The Next Generation' *Cell 144,* 646-674.
2. Weinberg R (2013) 'The Biology of Cancer' *Garland Science.*
3. Alberts B (2016) 'Molecular Biology of The Cell' *Garland Science.*
4. Kleinsmith L (2005) 'Principles of Cancer Biology' *Pearson.*
5. Lanza R. et al (2009) 'Essentials of Stem Cell Biology' *Elsevier.*
6. Considering the wide scope and dynamic nature of the topics being dealt with, review articles and research papers shall also be a major information resource.

Template of Theory Question paper
M.Sc. LIFE SCIENCE
Courses: 1001, 1002, 1003, 1004

CIA I – 20 marks, 45 mins.

Objectives/Short questions

CIA II – 20 marks, 45 mins.

Test/ Survey/ Assignment/ Presentation/ Poster/ Essay/ Review

End Semester exam – 60 marks, 2 hours

Choice is internal- within a unit and could be between 50% to 100%

M.Sc. Life Science

Practical Evaluation
Course: SLSC10PR

Research Project/ Literature Survey = 200 marks

For the project:
Internal: Literature survey = 25 marks, Laboratory work = 50 marks and Poster/ Paper = 25 marks
External: Dissertation = 60 marks and Final presentation = 40 marks