SOPHIA COLLEGE (AUTONOMOUS)

Affiliated to the University of Mumbai

Syllabus for Semesters V to VI

Program: B.Sc.

Course: Life Sciences

(Choice Based Credit System with effect from the year 2021-22)

PREAMBLE Programme:

B.Sc.

Course: Life Sciences (Semester–V&VI)

As mentioned in the outline of the syllabus, all the 08 courses of theory and Practical (Semester V and VI together) are compulsory to the students offering Life Sciences as a Single Major Subject.

These courses are:

1. SBSLSC501and SBSLSC601
2. SBSLSC502 and SBSLSC602
3. SBSLSC503 and SBSLSC603
4. SBSLSC504 and SBSLSC604

However, the students opting for Double Major Subject shall have following 04 courses of theory and Practical (Semester V and VI) compulsory:

1. SBSLSC501and SBSLSC601
2. SBSLSC502 and SBSLSC602

LIFE SCIENCE SYLLABUS

Choice based Credit and Grading System
Academic year 2021 -2022

SEMESTER V

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	LECTURES
Paper I	**Genetics and Immunology I**			
SBSLSC501	**1**	The Genetic material	**2.5**	**15**
	2	Mechanisms of Inheritance and variation		**15**
	3	Overview and cells and organs of immune system		**15**
	4	Antigen recognition and Effector Mechanisms		**15**
SBSLSCP501		Practical	**1.5**	
Paper II	**Developmental Biology and Neurobiology I**			
SBSLSC502	**1**	Developmental biology: concepts, Model organisms and techniques	**2.5**	**15**
	2	Animal and plant development – basic cellular aspects		**15**
	3	General organization of nervous system		**15**
	4	Cellular organization of the nervous system		**15**
SBSLSCP502		Practical	**1.5**	
Paper III	**Biotechnology and Genetic Engineering I**			
SBSLSC503	**1**	Fermentation technology– Principles	**2.5**	**15**
	2	Fermentation technology- Food and Beverage Production		**15**
	3	Tools in Recombinant DNA technology		**15**
	4	Techniques in Recombinant DNA technology and applications		**15**
SBSLSCP503		Practical	**1.5**	
Paper IV	**Environmental Biology I**			
SBSLSC504	**1**	Introduction to fundamentals of Environmental science	**2.5**	**15**
	2	Biodiversity and habitats		**15**
	3	Pest management and toxicology		**15**
	4	Sustainable development		**15**
SBSLSCP504		Practical	**1.5**	

SEMESTER VI

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	LECTURES
Paper I	**Genetics and Immunology II**			
SBSLSC601	**1**	Organisms and techniques used in the understanding of Genetics	**2.5**	**15**
	2	Tools and Techniques in Molecular Genetics		**15**
	3	Hypersensitivity, Infectious diseases, Vaccines and Immunodeficiency		**15**
	4	Transplantation, Tumor Immunology, Tolerance and Autoimmunity		**15**
SBSLSCP601		Practical	**1.5**	
Paper II	**Developmental Biology and Neurobiology II**			
SBSLSC602	**1**	Animal and plant development – Basic cellular and molecular aspects	**2.5**	**15**
	2	Applications of developmental biology		**15**
	3	Sensory and motor systems		**15**
	4	Neurobiological basis of behaviour		**15**
SBSLSCP602		Practical	**1.5**	
Paper III	**Biotechnology and Genetic Engineering II**			
SBSLSC603	**1**	Fermentation technology – Enzyme and Pharmaceuticals Production	**2.5**	**15**
	2	Tissue Culture biotechnology		**15**
	3	Applications of recombinant DNA technology		**15**
	4	Tools in genetic engineering Bioinformatics: Structural and functional Genomics, Comparative Genomics		**15**
SBSLSCP603		Practical	**1.5**	
Paper IV	**Environmental Biology II**			
SBSLSC604	**1**	Environmental degradation	**2.5**	**15**
	2	Natural resources		**15**
	3	Environmental impact study		**15**
	4	Society and environment		**15**
SBSLSCP604		Practical	**1.5**	

SEMESTER V

COURSE CODE: SBSLSC501

PAPER I GENETICS AND IMMUNOLOGY I

Genetics I: The course is designed to give students understanding of basic principles of Genetics. Brief History of Genetics, Organization of Genome and ways in which gene expression is regulated is covered in first unit. The next unit deals with genes are inherited, and how variation is introduced in the genome.

Immunology I: This course of Immunology is formulated to provide good knowledge of the immune system, its response and involvement in health and disease. While immunology as a *science* has been defined as the "science of self/non self discrimination", it also includes our innate ability to defend against microorganisms (Innate Immunity); and its ability to recognize and respond to fight the infections through Acquired Immunity. Specific topics being covered include antigens and antibodies, antigen- antibody interactions, antibody structure and formation, Effector responses etc.

Course Code	Title	Lectures (60L)
SBSLSC501	**GENETICS AND IMMUNOLOGY I**	**2.5 credits**
UNIT 1: The Genetic Material		**15 L**
Discovery of the genetic material: Griffith's experiment of 1928; Avery, McLeod and McCarty's experiment of 1944; Hershey-Chase's experiment – (Brief review, only for short notes.)		2
1. Organization of Prokaryotic and Eukaryotic Genome:		
1.1 Structural organization of Prokaryotic and Eukaryotic genome (CCC DNA, Nucleosome structure, higher orders of chromosome packaging, Solenoid model, zig-zag model)		3
1.2 Sequence complexity of DNA - Unique and repetitive sequences (SINE, LINE, Microsatellite, mini satellite DNA), Denaturation kinetics and CoT value and interpretation of Cot curves; C value paradox.		3
2. Gene regulation in eukaryotes		
2.1 Chromatin condensation (Euchromatin, heterochromatin) 2.2 Modification and remodelling by acetylation and methylation 2.3 Transcriptional regulation Cis-acting regulatory sequences, promoters and enhancers. Transcription activators and repressors.		3 4
UNIT 2: Mechanisms of Inheritance and variation		**15 L**
1. Inheritance pattern of Genetic Disorders in Humans Prognosis, Testing, of any human genetic disorder		2
2. Introduction to genetic recombination		2
2.1 Types of naturally occurring genetic recombination. (e.g Homologous/Non homologous/site directed)		2
2.2 Mechanism and proposed models for genetic recombination (e.g Holliday Model/Double strand break model)		
2.3 Advantages of genetic recombination during meiosis		2

3. Mutational Variation: 3.1 Natural biological mutagenic agents – Prokaryotic Transposable elements and their significance	2
3.2. A. Types of eukaryotic transposons, their mechanism of action,(e.g AcDs system in maize, P element transposition) and inheritance	4
3.2.B. Application of transposable elements in genetics	1
UNIT – III Overview and cells and organs of immune system	**(15L)**
3.1 Historical Perspective - Early Vaccination studies; Infection andimmunity	1
3.2 Overview of the Immune system - Innate Vs Adaptive Immunity 3.2 A. Innate immunity i) Anatomical, Physiological, Phagocytic, Inflammatory barrier ii) Concept of PAMP, PRR and TLR	2
3.2 B. Cells and organs of the immune system i) Cells - structure and functions – Myeloid cells, Lymphoid cells – B and T cells, NK cells ii) Primary and secondary lymphoid organs	3
3.3 Antigens and antibodies 3.3 A. Immunogenicity versus antigenicity i) Antigen-Specificity, avidity, affinity, cross reactivity, haptens, adjuvants, epitopes ii) Properties of immunogen contributing to immunogenicity 3.3. B. Antibodies i) Basic structure of antibodies ii) Classes of antibodies and biological activity iii) Polyclonal and monoclonal antibodies (Hybridoma technique)	1
3.3 C. Organization and expression of Immunoglobulin genes i) Multi gene organization and gene rearrangement ii) Generation of antibody diversity iii) Class switching	3
3.3 D. Antigen-antibody interactions – Principles and applications Precipitation, Agglutination, Radioimmunoassay, ELISA, Immunofluorescence, Western blotting, Flow cytometry, Surface Plasmon resonance	3

UNIT – IV Antigen recognition and Effector Mechanisms	**(15L)**
4.1 Recognition of antigens. **4.1A. Major Histocompatibility Complex** i. MHC molecules and genes ii. MHC allelic polymorphism iii. Cellular expression of MHC iv. Self MHC restriction of T cells	2
4.1 B. Antigen processing and presentation i. Endogenous antigens – the cytosolic pathway ii. Exogenous antigens – the endocytic pathway	2 2
4.3 Maturation and activation of Lymphocytes i. B- cell Maturation, Activation and Differentiation ii. T- cell receptor – Structure and role of αβ and γδ receptors iii. T cell receptor complex and accessory membrane molecules iv. T- cell Maturation, Activation and Differentiation	1 2
4.4 Immune Effector Mechanisms **i) Cytokines**- IL-1, IL-2, IL-4, IFNs and TNFs **ii)** Cytokine secretion by T_H1 and $T_H2$cells	1
4.5 Complement i. Classical, alternate and lectin pathways and comparison ii. Biological consequences of complement activation iii. Complement fixation tests	2
4.6 Cell-mediated effector responses Cell-mediated cytotoxicity of T cells, NK cells, ADCC Role of T_H1, T_H2,T_H17 and Tc cells	3

Practical Syllabus

Semester V

Course code: SBSLSCP05

[Practical Based on SBSLSC501, Credits-1.5, Lectures- 60]

Genetics

I) Experiments to be performed by students:

1. Extraction of chromosomal DNA from suitable sample (Chicken/goat/any other suitable source)
2. Streak plating of saliva on two different media and Gram Staining
3. Viable count for enumeration of bacteria by –Bulk seed method
4. Viable count for enumeration of bacteria by - Surface spread method

II) Demonstration experiments:

5. a) Study of *Drosophila* mutants from specimen / slides/photographs
   b) Collection and observation of virgin *Drosophila* females for setting up of genetic crosses
6. Study of UV-Visible Spectrophotometer using DNA/ Protein from suitable sample, checking purity of sample.

Immunology

I) Experiments to be performed by students:

1. Study of ABO Blood groups and quantitative Coombs Test.
2. Study of Isohemagglutinin titer in blood.
3. Quantitative Widal Test.

II) Demonstration experiments:

4. a) Dissect and expose the lymphoid organs of rat/photograph
   b) Study of Thymus, Spleen, and Lymph node tissue sections
   c) Observation of Blast cells in bone marrow of any mammal from slides/photographs.

COURSE CODE: SBSLSC502

PAPER II- DEVELOPMENTAL BIOLOGY AND NEUROBIOLOGY I

Developmental Biology I: The course will introduce to the students the basic concepts of developmental biology, which is the process by which animals and plants grow from a single original zygote. This module describes the important model systems and technique used to understand developmental process. The early process of animal development will be explained using the amphibian and chick as examples and plant development using Arabidopsis.

Neurobiology I: This module describes the anatomical organization of the nervous system and its early development. It also explains the cellular basis of nerve conduction within a neuron and transmission across synapses including a description of the neurotransmitters

Course Code	**Title**	**Lectures(60L)**
SBSLSC502	**DEVELOPMENTAL BIOLOGY AND NEUROBIOLOGY I**	**2.5 Credits**
UNIT 1 : Developmental Biology : Concepts, Model organisms and techniques		**15 L**
1.1 History of concepts in development		1
1.2 Some basic concepts of developmental biology: Overview: Development is a gradual process by which a complex multicellular organism arises from a single cell (the zygote). It involves 5 major overlapping processes: 1. Growth: increase in size 2. Cell division: increase in number 3. Differentiation: diversification of cell types 4. Pattern formation: organization 5. Morphogenesis: generation of shapes and structures		2
1.3 Life Histories of Model Organisms highlighting some important concepts: i. *Dictyostelium*- cell signaling and morphogenetic gradient ii. *Drosophila:* Overview of invertebrate body plan (Life Cycle and body plan) iii. Zebrafish *:*Overview of vertebrate body plan (Life Cycle and body plan)		6
1.4 Experimental approaches to studying development: i. Fate mapping and lineage tracing (Chick) ii. Mutations and large scale mutagenesis screens(Drosophila) iii. Transgenic techniques and gene silencing (Zebra fish/mice)		6
Unit 2: Animal and Plant development – Basic Cellular aspects		**15 L**
2.1 Development in Animals **2.1 a** Amphibian development- Germ cell formation: meiosis and cytoplasmic state of the egg; Fertilization: Cell signaling and Factors affecting fertilisation; Cleavage, Morula and blastula: Concept of potency and regulatory development; Gastrulation: Spemann's Organizer; Three germ layers and origins of organs; Neural tube Induction and formation of neural tube		**5**
2.2 b Chick development – In Comparison with amphibian in the processes of Germ cells and Fertilization, Cleavage, Morula and blastula, Gastrulation and Neurulation		**5**

2.3 Development in Plants Life cycle of Arabidopsis – sporophytic and gametophytic generation, Fertilization and embryo development, Development of meristems (root and shoot), Development of different organs – leaf, flower, androecium [including development of anthers, pollen grain, pollen tube etc.] and gynoecium [development of pistil - up to formation of embryo sac], Double fertilization, seed formation. [Eventual formation of fruit]	5
UNIT 3 :General organization of nervous system:	**15 L**
3.1. Comparative overview of vertebrate and invertebrate nervous system	
3.1.a Vertebrate nervous system: Anatomy and functional features of CNS (cerebral hemispheres, cerebellum, diencephalon, medulla, pons, midbrain and spinal cord),PNS (autonomous, somato sensory, cranial, spinal,plexii)	2 5
3.1.b Role of meninges and CSF, concept of blood brain barrier.	1
3.1.c Limbic System (emotions and memory)	1
3.1.d Hypothalamo – Hypophysial Axis(stress)	1
3.2 Development of the nervous system:	
3.2.a Specification of cell identity in the nervous system	1
3.2.b The formation and migration of neuron	1
3.2.c Axon navigation	1
3.2.d Synapse formation and refinement	2
UNIT 4: Cellular organization of the nervous system	**15 L**
4.2 Chemical Basis of Neural transmission- Introduction Ionic basis of resting membrane potential: types of ion channels, Nernst's potential, Goldman's equation, Sodium –Potassium pump	3
4.3 Action Potential & propagation: Hodgkin and Huxley's model, voltage clamp experiment and the generation and propagation of Action Potential, Graded potential. A comparative Plant example: Electrical signaling and closing of Venus fly trap.	3
4.4 Synaptic potential and synaptic integration [Electrical and Chemical Synaptic Potential] Excitatory Post Synaptic Potential (EPSP), Inhibitory Post Synaptic Potential(IPSP)	2
4.5 Synapse and synaptic transmission: Synapse: Structure, Types – Electrical and chemical; Neuro – muscular junctions; miniature endplate potentials(MEPPs)	2
4.6 Neurotransmitters – General Introduction Biosynthesis, physiological role, pharmacological significance, (examples of one agonist and one antagonist for each neurotransmitter mentioned below. Acetylcholine (Nicotinic and muscarinic receptors). Dopamine (D1 and D2 receptors). GABA and Glutamate, Neuropeptide (Endorphin and Enkephalin).	5

Course code:
SBSLSCP502

[Practical Syllabus Based on SBSLSC502, Credits: 1.5, Lectures : 60]

I) Developmental Biology:

Animals:

1) Study of developmental stages of chick embryo
2) Cytochrome C- oxidase activity in a developing chick embryo

Plants:

1) Effect of temperature on cell viability in pollen grains/yeast using Trypan blue/acetocarmine.
2) Root and shoot development in sections of a 2-day old plant embryo.

Demonstration experiments (Any two of the following):

1) Programmed cell death in limb bud using Janus Green B stain (in chick embryo).
2) Alizarin stain to study limb development in chick embryo/bone zebrafish
3) Acid and alkaline Phosphatase in Chick embryo / Alcian blue staining to study cartilage in zebrafish

II) Neurobiology:

1) Dissection& display of Nervous system in invertebrates –earthworm
2) Dissection & display of Nervous system in vertebrates – chick brain
3) Study of chick embryo for identification of fore, mid & hind brain areas (Refer above Developmental Biology Practicalno.1)
4) Study of Permanent slides of:

a) Medullary nerve fibre
b) TS of Spinal cord
c) Meninges

5) Electron micrographs of neural tissue

Demonstration Experiments (Any two of the following):

5) Study of the Nervous system of Sepia with special reference to Giant axon and stellate ganglia
6) Assignment - Bird songs and neurophysiology involved (as a group practical)
7) Understanding the principle and basic interpretation of brain imaging tests like PET and MRI

COURSE CODE: SBSLSC503

PAPER III- BIOTECHNOLOGY AND GENETIC ENGINEERING I

Biotechnology I: The course is designed to make students familiar with basics of fermentation techniques. Students will learn how food and beverages are produced at Industrial scale using fermentation.

Genetic Engineering I: This course is structured to make students understand basic tools utilized in Recombinant DNA technology. Students will be familiar with various enzymes, vectors, and analytical techniques that are fundamental to understanding of genetic engineering. Students should be able to plan cloning strategy of gene of interest by end of this course.

Course Code	Title	Lectures (60L)
SBSLSC503	**Biotechnology and Genetic Engineering I**	**2.5 Credits**
UNIT I: Fermentation technology – Principles		**15 L**
1.1. History and development of Food & Fermentation Technology		1
1.2. a. The Bioreactor / Fermenter & accessories (Stirred tank &Airlift)		1
b. Sterilization requirements in Bioprocess technology		1
1.3.a. Principles of microbial growth,		1
1.3.b. Screening (primary & secondary)		2
1.3.c. Strain improvement (mutation & selection using auxotrophy & analogue resistance		2
1.5. Media design for fermentation (include molasses, corn steep liquor)		2
1.6. Downstream processing		1
1.7. Instrumentation: Principles and technique of Centrifugation, Spectrophotometry & Chromatography		4
UNIT II: Fermentation technology - Food and Beverage Production		**15 L**
2.1. Technological aspects of industrial production of:		
2.1.a. Cheese/ Yoghurt		2
2.1.b. Beer/ Wine /Vinegar		3
2.1.c. Single Cell Protein		2
2.1.d. Mushroom		2
2.2. Food quality assurance: Regulatory & social aspects of food biotechnology		3
2.3. Intellectual Property Rights		3

UNIT III: Tools in Recombinant DNA technology	**15 L**
3.1: Tools in Molecular Biology	
3.1.a. Restriction Enzymes – Nomenclature, General nature of action, Major categories based on type of cut, two typical examples each and recognition sites	3
3.2.b.DNA joining strategies: DNA ligase, Homopolymer tailing, Adaptors, Linkers, Use of Alkaline Phosphatase.	2
3.2 Vectors in genetic engineering –	
3.2.a. Phages (λ, M13, SV40, Adenovirus)	4
3.2.b. Plasmids (pBR322, pUC with blue white screening), Ti plasmids in plants	3
3.2.c. Cosmids, Phagemids	1
3.2.d. YAC, BAC, PAC	2
Unit IV: Techniques in Recombinant DNA technology and applications	**15 L**
4.1. Gel electrophoresis	3
(Principle, technique and application of Agarose, PAGE, 2D-GE)	
4.2. Blotting	3
(Principle, technique and application of Western, Southern, Northern blotting)	
4.3. Polymerase Chain Reaction	1
4.3.a. Basics of PCR	
4.3.b. Variations of PCR – RT-PCR, QPCR (Principle, technique and application)	1
4.3.c. Variations in Primer – Nested PCR, Poison Primer Technique, Universal primers	1
4.4. Restriction mapping, DNA fingerprinting (Principle, technique, applications) - SNP, VNTR, RFLP, AFLP	4
4.5. Cloning of a gene (Somatostatin / Insulin)	2

Course Code: SBSLSC P503

[Practical Based on SBSLSC503, Credits-1.5, Lectures- 60]

1. Extraction and purification (salting out method) of enzyme: (Amylase from sweet-potato salivary amylase/egg white lysozyme or any other convenient enzyme)
2. Determination of - i) enzyme activity ii) specific activity.
3. Effect of inhibitors on Km of amylase/any other convenient enzyme.
4. Agarose gel electrophoresis of the extracted amylase or serum
5. Non-denaturing Poly Acrylamide Gel Electrophoresis of *E.coli* extract / Serum proteins / Saliva / Egg white any other suitable sample
6. Alcohol and sugar tolerance in yeast and strain improvement studies by exposing yeast to UV rays.
7. Gene Cloning strategy(Craft)
8. Sugar Fermentation rate in presence of different substrate/pH/temperature measure accumulated CO2 with under different conditions. (Demonstration / group experiment)
9. Microbial culture and Growth Curve.

COURSE CODE: SBSLSC504

PAPER IV-ENVIRONMENTAL BIOLOGY-I

This syllabus is designed to understand the environment around us. It introduces the fundamental concepts of environment and the biodiversity around us. The students will understand different features of a habitat, also the problems associated with their management and conservation. The issues and problems regarding the natural resources are featured along with detailed coverage on sustainability.

Course Code	Title	Lectures (60L)
SBSLSC504	**ENVIRONMENTAL BIOLOGY I**	**2.5 Credits**
UNIT I		**15 L**
1.1. Environmental History and Natural resources: Definition, Scope and Importance		1
1.1.a. Environmental History: Historical Modes of Resource Use: a) Gathering, b) Nomadic c) Settled cultivation d) Industry Controlled exploitation of natural resources: A case study of British India- timber/coal mining		2
1.1.b. Community Ecology: Concept of community (E.g. Forest as a community), Species Interaction, Prey Predator interaction. Food chain, Food web and Higher order interactions: Succession seral communities in secondary succession, redistribution of population after land fragmentation, loss of species (fire and succession).		3
1.1.c. Population ecology: Population parameters- Spacing, size and density, Age composition, Survivorship curves, recruitment, Population growth- logistic, exponential, Geometric growth.		2
Population cycles, population dynamics and models of population regulation: Competition and predation		1
Natality, Mortality, Biotic potential, Carrying capacity, density dependence, regulation. Improving carrying capacity and its application in wildlife management. Invasive species: example: *Lantana camara /Prosopsisjulifera*		3
1.2. Ecosystem dynamics:		1
1.2.a. Energy flow, primary and secondary productivity, Ecological Pyramids.		1
1.2.b. Soil Ecology: Soil Profile, Soil food web (components and interactions) sustainable soil management and agriculture.		1
1.2.c. Anthropogenic effects on Biogeochemical cycles of Carbon and Nutrient cycles (S, P and N).		

UNIT II	**15 L**
2.1. Biodiversity and Habitats:	
2.1. a. Biomes of the world: climate, vegetation and Geographical distribution pattern. Tropical biomes, desert, temperate, taiga and tundra biome.	1
2.1. b. Biological diversity of India: Indian Biogeographic Zones, climate and its impact on biodiversity.	2
2.2. Indian flora and fauna	
2.2. a. Indian forest and vegetation types: diversity of flora and fauna. Endangered, Endemic and Extinct Species of India: Threatened species categories of IUCN, threatened species of plants and animals in India and their reasons, Red data books.	1
2.2. b.Environmental biotechnology: Role of biotechnology in conservation of species, *in-situ* and *ex-situ* conservation, (concept of Gene Bank)	2
2.2. c. Wildlife management and conservation: Wild life management: Goals and Strategies., Human land-use and wildlife management – Elephant Corridor Vulture Conservation Centre, Haryana, (an BNHS initiative),Wildlife crossings.	2
2.3. India and Multilateral Environmental agreements	
2.3. a. Implications of Environmental Agreements to India: Ratification, Becoming a Signatory, Responsibilities, Obligations, expectations and challenges.	1
2.3.b. RAMSAR Convention on Wetlands	
2.3.c. IUCN (International Union for Conservation of Nature and Natural Resources)	1
2.3.d. Convention on Biological Diversity	
2.3.e. CMS (Convention on the Conservation of Migratory Species)	1
2.3.f. Basel Convention on the Control of Trans boundary Movement of Hazardous Waste and Their Disposal	1
2.3g. Kyoto Protocol	
2.3h. IWC (International Whaling Commission)	
2.4. Population and consumption Dynamics with special reference to Humans:	3
2.4.a. Energy and food production (grains, Livestock, aqua culture): Green revolution, Blue revolution. Nutrition: micro and macro nutrition, Ecological costs of food production. Organic Farming, Climate change and impact on Agriculture.	
2.4.b. GM foods and their environmental concerns eg .Bt Brinjal, Politics and economics of Hunger, Intellectual Property Rights (IPR), Biopiracy (e.g., Neem/Basmati) Relevance of Seed Bank.	

Unit III	**15 L**
3.1. Pest and pesticides:	
3.1.a.Basic introduction about Pests, Pesticides and Environment	1
3.1.b. Pesticide toxicity: Bioaccumulation and Biomagnification, persistence, resistance and pollution health of farmers. New methods of pest control: Biological pest control: predators parasites, and pathogens. Genetically Engineering and pest control, Integrated pest management	3
3.1.c. Bioremediation of pesticide: using *Bacillus* Sps.(eg. Malathion Pesticide)	1
3.1.d.Phytoremediation of Organochlorine pesticide(Chloropyrifos) using plants	2
3.1.e.Pesticide regulation: eg.Endosulphan issue.	
3.2.ToxicologyManagement:	
3.2.a. Toxicology: Basic concepts, toxicity and its impacts Distribution of Toxic material in the environment and Exposure risk assessment. Routes of entry, Absorption and translocation, fate of toxic agent Assessment of toxicity - Indices of toxicity(e.g. LD50, LC50, EL50, NOEL) Industrial toxicants and hazardous materials, toxic and hazardous waste management, measurement of toxicity, TLM and lethality studies, physiological and metabolic effects on flora and fauna.	3 1
3.2.b. Limitation of Toxicological studies: Comparison of animal toxicological models and Toxicity in Humans.	1
3.2.c. Human clinical trials: Concept of Clinical trial phases-I, 2, 3and Pharmacovigilance.	1
3.2.d. Ethical issues of clinical trials: (e.g. Thalidomide) and significance of Helsinki declaration.	1
UNIT IV	**15 L**
4.1 Community and Environment Conservation.	3
4.1a. Case study- Amur Falcon and tribal community of Nagaland	2
4.1b.Oneman role in conservation A Case Study – Dr. Rajendra Singh (Water man of India)	
4.1c. Role of local communities in wildlife management initiatives. Case study- Kokrabellur Village.	2
4.2. Citizen Awareness and environmental legal provisions:	3
4.2 a. Environmental Law and Constitution of India: Constitutional Provisions: Article 21,Article 48A, Article 51A(g), Environment protection Act1986,MoEF(1985)	
4.2b. Laws related to environmental protection and wildlife: The Environment (Protection) Act, 1986; The Forest (Conservation) Act, 1980; The Wildlife Protection Act, 1972; Water (Prevention and Control of Pollution) Act, 1974; Air (Prevention and Control of Pollution) Act, 1981 and Forest Rights Act, 2006. National Green Tribunal.	5

Coursecode: SBSLSC P504

[Practicals Based on SBSLSC504, Credits-1.5, Lectures- 60]

1. Plankton collection/Plankton identification and quantification from river/Lake water samples
2. Vegetation studies by line, quadrates and belt transect methods and their analysis.
3. Using a Simulated data perform the following: Classify the data and calculate ecological indices; Dominance index, Shannon-Wiener Index, Similarity Index, Diversity index. Evaluate and interpret each of the index values.(Any two examples)
4. Preparation of media for microbial culture, Isolation and culturing of microbes from soil/water samples (Fungal/Bacterial/Algal organism)**.**
5. Study of fecundity from the given sample of fresh water/ marine fish
6. Isolation and culturing of Rhizobium from the given sample
7. Analysis of soils for pH, moisture, soil types.
8. Water analysis for physicochemical characteristics:(any three)
   Salinity/Acidity/Alkalinity/BOD/DO/COD/Copper
9. Study of effect of a metal toxicity on the heartbeat of Daphnia and statistical analysis of the same t Test/LC50
10. A visit to a Nature Park/Mangrove

SEMESTER VI

COURSE CODE: SBSLSC601

PAPER I- GENETICS AND IMMUNOLOGY II

Genetics II: The course deals with organisms and techniques used in understanding molecular genetics. Students are expected to learn how genes are mapped on chromosomes. The second unit introduces principle and applications behind tools used in Genetics.

Immunology II : This course mainly deals with the section of immunology which encompasses the aetiology of various diseases caused by disorders of the immune system either due to its failure (immunodeficiency), aberrant action (Hypersensitivity, autoimmunity), or malignant growth of cellular elements (Cancer) and clinical management (Vaccines).

Course Code	Title	Lectures(60 L)
SBSLSC601	**Genetics and Immunology II**	**2.5 credits**
UNIT 1: Organisms and techniques used in the understanding of Genetics		**(15 L)**
1. Genetic recombination and Gene mapping (Processes and numerical problems)		
1.1 Bacterial Conjugation		1
1.2 Three factor crosses in maize		2
1.3 Co-efficient of co-incidence and interference in Drosophila		2
1.4 Complementation analysis in Humans using Haemoglobin		2
1.5. Life Cycle of lytic and lysogenic phages; Deletion mapping		2
2.Human Genetics		3
2.1. Human Genetic Maps, Somatic cell Genetics: Use of cell hybrids and hybridomas for gene mapping; The lod Score Method for Analyzing Linkage of Human Genes		3
2.2 The Human Genome Project : aims, major features and applications(e.g. detecting polymorphism, personalized medicine)		
UNIT II: Tools and Techniques in Molecular Genetics		**(15L)**
3.1 Agarose gel electrophoresis (Principle, methodology, Applications)		2
3.2 Polymerase Chain Reaction (Principle, methodology, Applications)		2
3.3 Restriction enzymes and Restriction mapping		2
3.4 DNA Sequencing – Sanger's Method, Next GenSequencing		2
3.5 PCR based methods of Induced mutagenesis (Site-Directed mutagenesis, Cassette mutagenesis)		2
3.6 Mutagenicity testing – Ames test, Sister chromatid exchange test, mouse specific locus test (Advantages and disadvantages)		1
3.7 Nucleic acid in situ Hybridization (FISH) and Chromosome painting		1
3.8 Hybrid arrest and Hybrid release method (HRT and HART)		1
		1

UNIT – III: **Hypersensitivity, Infectious diseases, Vaccines and Immunodeficiency**	**(15L)**
3.1 Hypersensitivity Gell and Coombs classification: Types of hypersensitivity – Examples and methods of diagnosis i) IgE- mediated (Type I) hypersensitivity mechanism, mediators and control methods: RIST and RAST ii) Antibody-mediated (Type II) hypersensitivity: Agglutination iii) Immune complex-mediated (Type III)hypersensitivity: Immunofluorescence, ELISA iv) Delayed type hypersensitivity (Type IV): Tuberculin test	5
3.2 Infectious Diseases and Vaccines 3.2.aImportant immune mechanisms against various infectious diseases i) Viral infections ii) Bacterial infections iii) Fungal infections iv) Parasitic infections 3.2 b. Vaccines i) Passive immunization - Preformed antibodies and their disadvantages ii) Use of Chimera / humanized antibodies iii) Active immunization-Whole organisms (attenuated vs. inactivated eg. Polio) iv) Subunit Vaccines (Polysaccharide, toxoid and peptide vaccines) v) DNA vaccines	7
3.3 Immunodeficiency: Primary and acquired Immunodeficiency a) Primary immunodeficiency i) B-cell- X-linked agammaglobulinemia ii) T-cell- Di George Syndrome iii) Lymphoid deficiency - Severe Combined Immunodeficiency iv) Deficiency of myeloid lineage- Chronic Granulomatous Disease b)Acquired Immunodeficiency i) Acquired Immunodeficiency Syndrome	3

UNIT – IV : Transplantation, Tumor Immunology, Tolerance and Autoimmunity	(15L)
4.1 Transplantation i) Types of grafts ii) Tissue typing (serological and MLR) iii) Mechanisms of graft rejection iv) Immunosuppresive therapy v) Graft vs. host disease - bone marrow transplant	4
4.2 Tumor Immunology i) Tumor specific and associated antigens ii) Role of NK cells and macrophages iii) Tumor evasion of immune system iv) Cancer immunotherapy.	4
4.3 Tolerance and Autoimmunity 4.3.a Establishment and maintenance of tolerance i) Mechanisms of central tolerance ii) Mechanisms of peripheral tolerance iii) Role of T regulatory cells iv) Immunology of pregnancy	4
4.3 b. Autoimmunity i) Mechanisms for induction (Aetiology) ii) Organ specific diseases – ex. Myasthenia gravis, Graves disease iii) Systemic diseases – ex. Systemic Lupus Erythematosus, Multiple sclerosis	3

SEMESTER VI
PRACTICALSYLLABUS

Course code: SBSLSCP601
[Practical Based on SBSLSC601, Credits-1.5, Lectures- 60]

Genetics

I) Experiments to be performed by students:

1. Giant Chromosome preparation (*Drosophila*/*Chironomus*)
2. Estimation of bacteriophage titre by plaque assay
3. Effect of UV light on microorganisms - Determination of percent viability of an *E. coli* culture after U.V. exposure- in the absence of light repair
4. Isolation of antibiotic resistant / auxotrophic mutants using Replica plate technique.

II) Demonstration experiments:

5. Extraction of plasmid DNA, restriction enzyme digestion and visualization by agarose gel electrophoresis.

Immunology

I) Experiments to be performed by students:

6. Ouchterlony test for Immunodiffusion (Qualitative).
7. Mancini test – Single Radial Immunodiffusion(Qualitative)
8. Agarose slide gel electrophoresis of Serum.

II) Demonstration experiments:

9. Separation of Mononuclear cells using a gradient and the determination of viable count of the same
10. SDS- PAGE for separation of IgG subfraction
11. Qualitative ELISA using albumin

COURSE CODE: SBSLSC602

PAPER II- DEVELOPMENTAL BIOLOGY AND NEUROBIOLOGY II

Developmental Biology II: This module explains the molecular and cellular aspects of and the important genes involved in early development. This module also looks at the applications of Developmental Biology such as regeneration, ageing, cancer and assisted human reproduction

Neurobiology II: This module describes the structural and functional features of the various sensory and motor systems. It elaborates on some behavioural aspects such as sleep and memory. Examples of diseases that arise due to malfunction of the nervous system are described.

Course Code	Title	Lectures (60 L)
SBSLSC602	DEVELOPMENTAL BIOLOGY AND NEUROBIOLOGY II	2.5 credits
UNIT 1: Animal and Plant development – Basic Cellular and Molecular Aspects		(15L)
1.1 Potency: Totipotency (Nuclei), Pluripotency (Inner cell mass/embryonic stem cells), Multipotency (mesenchymal stem cells), Oligopotency (Monocytes)		2
1.2 Determination and Trans determination (Imaginal Discs)		
1.3 Differentiation: Hematopoietic stem cells and Neural crest cells (migration and differentiation)		3
1.4 Molecular basis of development i. Genes in early development (with *Drosophila* as example) ii. Determination of anterior- posterior and dorso-ventral axis iii. Role of Maternal genes and zygotic (Gap genes, pair-rule genes, iv. Segmentation genes and Homeotic genes) v. Beta globin gene – as an example of change in gene expression		3
1.5 Conserved nature of developmental genes (Evo- Devoperspective Hox/Pax6 genes with respect to Drosophila)		2
1.6 Organogenesis of Eye OR Limb with references to inductive/ instructive signals, cytoplasmic determinants and gradients		1 2
1.7 Plant Development i. Role of Homeotic genes specifying parts of a flower: Classical ABC Model (ABCD and ABCDE model on floral evolution to be given as assignment)		
ii. Plant genome project (Arabidopsis/rice)		2
UNIT 2: Applications of Developmental Biology		(15L)
2.1 Assisted human reproduction		1
2.2 Regeneration a. Examples in animal world (vertebrates and invertebrates) b. Epimorphic (Salamander limb) and Morphallactic (Hydra) c. Compensatory regeneration (mammalian liver) d. Recent advances in stem cells and regenerative medicine (student assignment)		4
2.3 Aging- Theories of Aging		2
2.4 Congenital abnormalities : sensitive periods during development and causes of congenital abnormalites with special references to the following		3

a. Zika virus b. Alcohol c. Spina bifida **2.5 Cell cycle regulation** - check points in cell cycle and role of cyclins and cdks	1

2.6 Apoptosis and its role in development	1
2.7 Cancer- Types of Cancer, Causes of Cancer, Oncogenes, Tumour suppressor genes, Treatment strategies for Cancer (example breast cancer)	2
Unit 3: Sensory and motor systems	**(15 L)**
3.1 Introduction to Human Sense organs: receptors, receptor mechanisms and pathways	1
3.1.a Visual system: Vision - structure of the eye, retina, photoreceptors (rods and cones), photo transduction, binocular vision, visual pathway (flow chart only – LGN to visual cortex), light & dark adaptation, colour vision.	2
3.1.b Auditory System: Structure of the ear, cochlea and organ of corti receptors 1 Mechanism of transduction, Auditory pathway: (MGN to audio cortex) Diagrammatic representation only.	2
3.1.c Vestibular System: Structure of the vestibular labyrinth, maculae and cristae. Mechanism of transduction.	2
3.1.d Chemosensory system: Olfactory and Gustatory receptors –structure.	2
3.1.e Skin as sense organ: somatic receptors - Types of mechano- receptors, pain reception& Pain management (example analgesic effect by prostaglandin inhibition - aspirin)	2
3.2 Motor System:	1
3.2.a Organization, Reflex Coordination(ascending and descending pathways diagrammatic representation only)	1
3.2.b Role of cerebellum in motor co-ordination	1
3.2.c Types of muscles, Molecular basis of Muscle contraction	1
3.2.d Reflexes: Simple reflex arc, mono and poly-synaptic reflexes (one example of each)	
UNIT 4 : Neurobiological basis of behaviour	**(15 L)**
4.1.a Sleep, Stages of sleep – REM and non REM	4
4.1.b Short term memory and Long Term Memory (eg. Pathway in Aplysia and molecular events)	4
4.2 Neurobiological basis of Diseases: 4.2.a Epilepsy 4.2b Parkinson‟s disease 4.3c Schizophrenia- Relevance with regard to neurotransmitters 4.4d Prions associated diseases 4.5e Duchene‟s muscular Dystrophy 4.5f Alzheimer‟s disease	7

Course Code: SBLSCP602

[Practical Syllabus Based on SBSLSC602 Credits: 1.5, Lectures: 60]

I) Developmental Biology

Plant

1. Effect of boron / calcium on pollen tube germination pollen tube length in *Vinca rosea* or any other suitable sample
2. Role of GA in seed germination.
3. Demonstration experiments: Plant Tissue Culture: Initiation of plant tissue culture from neem and /or carrot callus/any other suitable source: (project to be performed in groups of 4-5students)

Animal

4. Live observations of Developmental stages of *C.elegans/Dictyotelium/Drosophila/Zebrafish*
   Demonstration experiments: (Any two)
5. Imaginal discs of *Drosophila*
6. Regeneration in earthworm / any other suitable system /hydra
7. Animal Cell Culture /Assays: Cell proliferation assay/ Cell migration assay/ Cell adhesion assay

II) Neurobiology

1. Differential staining of white and grey matter of vertebrate brain.
2. Temporary mounts of the following (Any three):
   a) Cornea of prawn.
   b) Statocyst of prawn.
   c) Columella of bird.
   d) Striated / smooth muscle fibre.
   e) Methylene blue staining of earthworm nerve cord or any other suitable nerve cord
   f) Olfactory & gustatory sensillae
   g) Histological staining of neuronal tissue using Heamotoxilin-Eosin staining or Nessil's staining.

3) Making clay model of vertebrate brain and cranial nerves
4) Demonstration Experiments
1. Stroop test.
2. Olfactory /Gustatory Behavioral study: Snail / Earthworm / insect larvae
3. Associative conditioning
4. Knee-jerk and pupillary reflex.
5. Testing for locating the Blind Spot in the retina
6. Mammalian retina (Study of Histology)

COURSE CODE: SBSLSC603

PAPER III- BIOTECHNOLOGY AND GENETIC ENGINEERING II

Biotechnology II: This course deals with details of applied aspects of Biology. Students will learn how fermentation technology, and plant / animal tissue culture are used for production of various pharmaceutically important compounds.

Genetic Engineering II: In this course students will learn about Applications of tools and techniques in Recombinant DNA technology. They will also learn about bioinformatics and Genomics. Students should be aware of vast scope of Genetic Engineering in transforming human lives by end of this course.

Course Code	Title	Lectures (60L)
SBSLSC603	**Biotechnology and Genetic Engineering II**	**2.5 credits**
Unit I Fermentation technology – Enzyme and Pharmaceuticals Production		**(15 L)**
1.1. Enzyme Technology		
1.1.a. Enzyme production ex. Amylase (bacterial / fungal)		3
1.1.b. Immobilized Biocatalyst (method of immobilization, applications –biosensors)		2
1.2. Application of fermentation technology in medicine:		
1.2.a. Production of antibiotics (Penicillin)		2
1.2.b.Vitamins (Vitamin B12)		2
1.2.c. Vaccines (polio / HbsAg)		2
1.2.d. Probiotics, Neutraceuticals (one example of each)		2
1.2.e. Biopharmaceuticals/Biomolecules (Insulin/IFN)		2
UNIT II Tissue Culture biotechnology		**(15 L)**
2.1. Application of fermentation technology in Agriculture		
Biopesticides – bacteria (*B.thuringiensis*)		4
Virus (*Polyhedrosis* virus)		
fungal (*Trichoderma)*		
2.2. Plant and Animal Tissue culture:		
2.2.a. Animal – Laboratory setup, Media, Basic techniques (Disaggregation of tissue and primary culture, maintenance of cell lines- see also Practicals)		4
2.2.b. Plant – Media, Basic techniques (callus and suspension culture, organogenesis, & somatic embryogenesis, Protoplast isolation and fusion)		4
2.2.c. Secondary metabolites and Biotransformation in plant tissue culture		3

Unit III: Applications of recombinant DNA technology	**(15 L)**
3.1.Knockouts, Knock in, Knock down systems(Transgenic animals)	2
3.2. Transgenic plants: Bt cotton and weedicide resistant gene (any one example)	2
3.3. Xenopus oocyte as an expression system	1
3.4. Giant Mouse (MMT promoter growth hormone fusion gene)	1
3.5. Drosophila (using p element mediated technique-enhancer trap)	1
3.6. Transformation of Plant Cells and Applications for Plant Genetic Engineering:	1
3.6.a. Microinjection method	
3.6.b. Ti plasmid based Vectors (Binary vector and Co-integrative vector)	1
3.7. Applications in industry – Medical/pharmaceutical, agricultural	1
3.8. Gene therapy using any one example (Parkinson disease/SCID)	1
3.9. Ethical, Legal , and Social Implications of recombinant DNA technology	2
3.10. Consumer awareness (Labelling of GM food)	1
Unit IV: Tools in genetic engineering, Bioinformatics: Structural and functional Genomics, Comparative Genomics	**(15 L)**
4.1 Tools in genetic engineering	
4.1 a. Preparing genomic and cDNA libraries	2
4.1.b. Screening techniques (Nucleic acid hybridization methods, immunological methods, gene inactivation)	2
4.1.c.Microarrays	
4.1.d. Brief overview of Cre-Lox system	2
4.2 Bioinformatics: Structural and functional Genomics	
4.2.a. Biological databases (formats: FASTA and GenBank)	2
4.2.b. Sequence annotation and comparison	
4.2.c. Assigning Gene/protein Function Experimentally	
4.2.d. Applied genomics: Drug designing and basic concept of Docking	4
4.3 Comparative Genomics	
4.3.a. Sequence alignment [Pairwise alignment (BLAST), Multiple alignment (CustalW)]	
4.3.b. Phylogenetic trees (Rooted, Unrooted, Concept of Boot-strapping)	
4.3.c. Examples of Comparative Genomics Studies and Uses	3

Coursecode: SBSLSC P603

[Practicals Based on SBSLSC603, Credits-1.5,Lectures- 60]

1. Thin layer chromatography of lipids/plant alkaloids/any other suitable extract
2. Bioassay of antibiotic / plant extract / for anti-bacterial activity orB-12assay.
3. Assay of fermentation product / Substrate – Estimation of (a) alcohol/Acetic/lactic acid(b)
4. Extraction of plasmid DNA& Agarose Gel Electrophoresis of plasmid DNA/Restriction Digest with costing of the experiment.
5. Immobilization of Enzyme (Amylase/any other convenient enzyme) using hen egg-white or alginate method and assay its activity.
6. Quality control: Probiotics or Vaccine
7. Bioinformatics:

   i) Design primers (Forward and reverse primers with matching Tm) for amplifying "x" gene of "y" species. (They will search for sequence, and design primers)

   ii) Manual annotation of DNA sequence: Prokaryotic/Eukaryotic

   iii) Sequence alignment – pair wise (For Match Score: Specify values for match, mismatch and gap penalty)

   iv) Construction of Cladogram/Phylogram with Time Line

Open-ended projects:(Anyone of the following, along with its costing)

1. Home-Wine production / Home-Vinegar production from any convenient source & assay for fermentation products
2. Culturing & biomass estimation of mushroom/ Spirulina /chlorella by cell count/dry weight and estimation of percentage total protein.
3. Plant tissue culture: i) Callus production ii) Preparation of protoplasts and estimate viability by trypan blue staining
4. Animal tissue culture: Tissue dissociation by trypsinization technique and to estimate the viability of cells in physiological saline/MEM at 0 hrs and2hrs
5. Growth curve of E coli (DH5 alpha) and preparation of competent cell for transformation experiment.
6. Finger Printing technique using electrophoresis of protein/DNAdigest38
7. SDS PAGE with suitable Protein sample for Comparison with Experimentno.3above.
8. Agarose Gel Electrophoresis of extracted DNA samples with & without Molecular marker ladder
9. Genomic DNA extraction, purification and estimation by UV spectroscopy Development of cost effective method using Liquid Soap, Common Salt and Alcohol or any convenient variation

COURSE CODE: SBSLSC604

PAPER IV - ENVIRONMENTAL BIOLOGY II

ENVIRONMENTAL BIOLOGY II: The paper deals with the human dimension of development and its effect on environment. It aims to provide adequate insight on management of natural resources. It introduces critical issues in environmental studies, both in an Indian and global perspective. The process of urbanization is explored with respect of consumption of resources; environmental consequences of urban transformation, waste disposal and pollution.

Course Code	Title	Lectures (60 L)
SBSLSC604	ENVIRONMENTAL BIOLOGY II	2.5 Credits
UNIT I		(15L)
a. **Environmental effects of urbanization:** Availability of public/open and green spaces/sustainable use of urban space)		1
b. **Expansion pattern of cities**- Megacities, smart cities and Eco-cities, problem of Urban sprawl.		2
c. **Urban growth Challenges**: Drinking water supply, Air pollution, generation of waste and waste management.		2
d. **Rural environmental degradation**: (a) deforestation; (b) declining soil quality (including soil desiccation); and (c) loss of biodiversity.		2
e. **Use of fresh water Resources**: ground water, contamination of ground water, rural sewage management, freshwater wet lands, Rural Migration, Impact of cities on rural environment.		3
f. River linking Project: Ken and Betwa river.* to be given as Student Assignment		
g. Impact of environmental degradation on rural women		
h. **Toxic and solid waste management**: Types of waste, solid waste disposal, E-waste and toxic waste trading, economics of recycling, recycling plastic, Biocomposting and producing less waste.		1 4
UNIT II		(15L)
a. **Energy and Environment:** Classification of Energy resources, Types of renewable and Non-renewable energy resources.		2 2
b. **Evaluating energy resources:** Nuclear Power, Coal, Natura l Gas, Biomass burning, Gas turbines and Biofuels.		2
c. **Alternative Energy Resources:** Geothermal, Tidal/Wave power, Ocean		2
d. Thermal Energy, Inland Solar ponds, Energy efficient buildings		2
e. **Meeting the growing demands:** Transportation, residential, commercial and industrial needs.		2
f. **Meeting energy efficiency:** Household connected devices		2
g. Concept of carbon credit and carbon footprint		1

UNIT III	**(15L)**
1. Environmental Impact Analysis of a Development Project	
a. Risk management (EIA and Environment protection agency) perception of and gain, setting up standards	3
b. Preparation of EIA report: For e.g.: Selection of a Land fill site. For e.g.: Post Chernobyl disaster.	4
2. Environmental Audit	
a. Definition, Types of Audit, Processes and decision making. Environmental Audit of an Industry eg: Sugar factory	5
b. Environmental Audit of Solid waste Management eg. Bangalore City	
3. Environmental Justice Movement:	
a. Narmada Bachao Andolan and Project Affected people.	3
b. Chipko Movement, Hargila Army– Conservation efforts in Assam	
c. Bauxite Mining and Battle for Niyamgiri Hills.	
d. Plachimada struggle against destruction of groundwater	
UNIT IV	**(15L)**
1. Sustainable Development	
a. UN Agenda for sustainable development.	
b. Sustainable development goals (Global goals),2030	3
c. War and Sustainability: Eg. Consequences of Vietnam war. Cost benefit analysis	
2. Safety, Health and Environment:	
a. Safety and Health Hazards: Identification of potential safety and health hazards in industrial and development projects, reduction strategies, policies and legislation.	4
b. Lessons after 30 years of Bhopal gas tragedy	3
c. International and national perspective, safety standards and management systems, ISO 18000 (Occupational Health and Safety Management Systems)	4
d. Consumption Dynamics with special reference to Human	
e. Land scape Ecology: Effects of changing landscape pattern on organisms, populations, communities and ecosystem processes. Use of GIS and Remote sensing technology in Land use mapping. - case study of Bangalore city.	1

Course Code: SBSLSC P604

[Practical Syllabus Based on SBSLSC604SemesterVICredits:1.5, Lectures: 60]

1. EC, conductivity,N/P/K/Sulphates/Na/Ca. /EstimationofCo^{2+}and Ni^{2+}by colorimetry/spectrophotometry/ Water analysis for physico-chemical characteristics/Estimation of Heavy metal in various samples by titrimetry or spectrometry/Potability of the given drinking water sample by MPN. (Any three of the above)
2. Estimation of Co2+ and Ni2+/Pb by colorimetry / spectrophotometry (Anyone)
3. Remote Sensing and GIS: Principles of Remote Sensing and its application of Environmental Science. Application of GIS in Environmental Management (Use photographs and models).
4. Collection and Interpretation of weather data/Climatology of Mumbai city (Satellite images and statistical analysis of weather data).
5. Study of anatomical modifications and plant habitat
6. Study of Leaf margins as climate indicators.
7. Estimation of stomatal index (2 different leaf types and two different micro-climatic conditions e.g. Sun loving, shade loving)/Chlorophyll content.
8. Field visit to river/lake and waste water treatment plants.
9. A visit to National Park. Identification of local plant species as: Ecological indicators, exotic species
10. Environmental Project(compulsory)
    a. *The film documentary/Video making for project should notbemorethan10 min duration. Example: food sustainability, environmental justice and climate change, Sustainable future.
    b. Project Submission and viva

Note: All practicals in each course in both semesters have to be understood in terms of Instrumentation, Technique, Concept and Relevance *or whichever may be applicable*

Text Books and References

Reference Books for Paper I

Unit I and II – Genetics (SBSLSC501 and SBSLSC601)

1. Principles of Genetics by Snustad and Simmons 4th edn. John Wiley andsons,2006.
2. iGenetics; A Molecular approach by Peter Russel 2nd edn.Pearson,2006.
3. iGenetics; A Mendelian approach by Peter Russel 2nd edn.Pearson,2006.
4. Introduction to Genetic Analysis by Griffiths et al 8th edn Freeman andco.,2005.
5. Genes IX by Benjamin Lewin; Jones and Bartlettpublishers,2008.
6. Principles of Gene Manipulation and Genomics by S. B. Primrose and R. M. Twyman 7th ed., Blackwellpublication,2007.
7. Concepts of Genetics by W. S. Klug and M. R. Cummings 7th ed.Pearson,2003.
8. Concepts of Genetics by W. S. Klug, M. R. Cummings, C. A. Spencer 8th ed.Pearson,2006.
9. Human Molecular Genetics by Tom Strachan and Andrew Read, 3rd ed. Garland Sciencepub.,2004.
10. Principles of Genetics by R. Tamarin, 7th ed, BrownCo.,2002

Unit III and IV – Immunology (SBSLSC501 and SBSLSC601)

1. Immunology by R.A.Goldsky, T. J. Kindt, B. A. Osborne, J. Kuby, 5th ed.W. H. Freeman,2006.
2. Immunology: The immune system in health and disease by C. A. Janeway, P. Travers, M.Walport, M. Shlomchik, 6th ed, Garland Science Pub., 2005.
3. Cellular and Molecular Immunology, by A. K. Abbas, A. H. Litchman, 5th ed, Saunders,2003.
4. Basic Immunology: Functions and disorders of the immune system, by A. K. Abbas,A.H. Litchman, 2nd ed Saunders,2004.
5. Roitt‟sEssentialImmunology,byPeterJ.DelvesSeamusJ.MartinDennisR.BurtonIvanM.Roitt,11th ed, Blackwellpublication,2006.
6. Immunology by D. Mole, J. Bronstoff, D. Roth, I. Roitt, Mosbey, 7th Internationaled, Elsevier, 2006.
7. An Introduction to Immunology by C. V. Rao, Narossa Publishers,2002.

Reference books for Paper II

UNIT l and II - Developmental Biology (SBSLSC502 and SBSLSC602)

1. Instant Lecture Notes- Developmental Biology, R.M.Twyman, 1st ed, Viva Books Private Limited,2001
2. Principles of Development by L. Wolpert, Cheryl Tickle, 4th ed, Oxford UniversityPress.,2011
3. Developmental Biology byScott F Gilbert, 10th ed, Sinauer Associates Inc.Publishers,2013
4. Molecular Biology of the Cell by B. Alberts, D. Bray, J.Lewis, M. Raff, K.Roberts and J.D.Watson. 3rd ed, Garland Publishing Inc., N T andLondon,1994
5. Plant Cell and Tissue Culture by I. Vasil and T.A. Thorpe. Kluwer AcademicPublishers,1994
6. Practical Zoology by K.C. Ghone and B. Manna, 2nd ed, New Central Book Agency Publishers,2000
7. Pollen Biology – A laboratory manual by K.R. Shivanna and N.S. Rangaswamy,Narosa Publishing,1992.
8. Developmental Biology by L.W.Browder, 2nd edition Saunders College PublishingCo.,1985
9. Developmental Biology – Patterns, Problems and Principles by J. W. Saunders. 6th ed, MacMillan PublishingCo.
10. An Introduction to the Embryology of Angiosperms by P. Maheshwari, Nabu Press,2011

UNIT III and IV- Neurobiology (SBSLSC502 and SBSLSC602)

1. Neuroscience: Exploiting the brain by M.F.Baer, B.W.Connors&M.A.Paradiso, William& Wilkins, Baltimore,1996
2. Neurobiology by G.M. Shepherd, 3rd ed, Oxford UniversityPress,1994
3. Principles Of Neural Science by E.R.Kandel, J.H.Schwartz and T.M. Jessel, 5th ed, McGraw Hill, 2012
4. Instant Notes – Neurosciences by A.Longstaff, Viva Books Pvt Ltd., NewDelhi,2002
5. Text Book Of Medical Physiology by A.C.Guyton and J.E.Hall,13th ed, Saunders CollegePublishers,2015.
6. Elements Of Molecular Neurobiology by C.U.M. Smith, 3rd ed, J Wiley and SonsPublishers,2007
7. An Introduction to Molecular Neurobiology by Z.W. Hall, Sinauer Associates Inc.Publishers,1992
8. Ion Channels – Molecules in Action by D. J. Aidley,P.R. Stanfield, CambridgeUniversity Press, 1996
9. Physiology Of the Nervous Systems by D Ottoson, McMillan Press,1983
10. Neuroscience by Dale Purves, 3rd edition, Sinauer Associates,2004

Reference books for Paper III

Unit I to II – Biotechnology (SBSLSC503 and SBSLSC603)

1. Industrial Microbiology byL.E.Casida, New Age International (P)Ltd.,2003
2. Industrial Microbiology by Prescott And Dunn's, Chapman &Hall.,2003
3. Industrial Microbiology by A H PATEL, MacmillanIndia.2005
4. Principals of Fermentation Technology by P.F Stanbury, Whitaker and Hall,3rd ed, Elsevier,2016
5. Plant Cell and Tissue Culture by I. Vasil and T.A. Thorpe, Kluwer AcademicPublishers,1994
6. Animal Tissue Culture by Ian Freshney, 6th ed, Wiley-Blackwell; 2010

Unit III to IV–Genetic Engineering (SBSLSC503 and SBSLSC603)

1. Principles of gene manipulation and Genomics by Primrose and Twyman, 7thed, Blackwell,2006
2. Molecular Techniques in Biochemistry and Biotechnology by S Shrivastava, New central book Agency (P)Ltd, 2006
3. Molecular Biology by Robert Weaver, 2nd ed, McGraw Hill,2003
4. Text book of cell and Molecular Biology by Ajoy Paul, 2nd ed, Books and Allied (P) Ltd.,2009
5. Cell and molecular biology by Vyas and Mehta, CBS pub and DistPvtLtd.,2009

Reference Books for Paper IV

Unit I to IV–Environmental Biology (SBSLSC504 and SBSLSC604)

1. Essential environmental studies by Misra and Pandey, AneBooks,2011
2. Health and climate change by Martens, EarthScan,1998
3. Environmental Analysis of soil and airby Saxena, Agrobotanica,1998
4. Energy efficient and environment friendly technologies for rural development by Chakraborti, AlliedPublishers,2005
5. Ecology, chemistry and Management of environmental Pollution by Dash M C, Mac MillanIndia,2004
6. Sustainable sewage water Management by Nayak and Amar, Mc MillanIndia,2006
7. Endangered animals by Dolder, Willi, Parragon,2009
8. Methods in environmental Analysis by Gupta P K, Agrobio(India),2000
9. Frontiers of Environment : Issues in Medieval and Early Modernby BhargavaMeena, Oxford University Press, 2005
10. Vulnerable India by Kapur, SAGE,2010
11. Silent Invadersby Jacob, Miriam, Orient Longman,2004
12. Ecologyby Subramnyam, 2nded.Narosa, 2006
13. Environmental Biotechnologyby Dilip Kumar, Rajvaidya, APH,2004
14. Ozone Depletion and Environmental Impacts by Sharma and Khan, Pointerpublishers,2004
15. State of India's Environment 2020. - A Down To EarthAnnual.
16. Environmental Justice: Concepts, Evidence & politics by Walker,Gordon, RoutledgePublishers,2012
17. This Fissured Land An Ecological History of India by Gadgil, Madhav; Guha Ramachandra, Oxford University Press,2012
18. Water: Growing Understanding,Emerging Perspectives by Shah Mihir; Vijayshankar: P. S, OrientBlackSwan,2016
19. Environmental Studies and Green Technologiesby Garg Santosh Kumar & Garg Ranjini, KhannaPublisher, 2018
20. Climate change and Paris agreement: Challenges after US withdrawal by Pradeep Chauhan, New Century Publications,2019
21. Environmental Science: A global concern by Cunningham William P, 14th ed,McGraw-Hill Education,2017
22. Origin: The corporate war on nature and culture by Shiva Vandana and others, NATRAJ PUBLISHERS2018
23. The twice born: Life and death on the Ganges by Taseer, Aatish, Farrar, Straus and Giroux,2019