UNIVERSITY OF MUMBAI

Syllabus for the M.Sc. Part – I: LifeSciences

Semester I and II

Choice Based Credit and Grading System The academic year
2016-17

Program Objective

- To generate interest in biological sciences.
- To give an insight on advancement of understanding life processes.
- To develop skills in the techniques and technology in biology.
- Training for competitive examinations for further studies in Biology.

Program Outcome

- Acquire in depth knowledge of biological systems.
- Extend the knowledge of life processes to explore the biological systems.
- Enhance employability.
- Prepare candidates for higher education.

M.Sc. Part - I Life Sciences Syllabus

Choice based Credit and Grading System

The Academic year 2016-2017

SEMESTER I

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	L / WEEK
Paper I	**Environmental Biology, Evolution, Genetics**			
PSLSCT101	I	Environmental biology	4	4
	II	Biodiversity		4
	III	Evolution		4
	IV	Genetics		4
Paper II	**Cell and Molecular Biology**			
PSLSC102	I	Cell Biology	4	4
	II	Cell cycle and cell death		4
	III	Basics of life Processes I		4
	IV	Basics of life Processes II		4
Paper III	**Biochemistry**			
PSLSC103	I	Proteins and Lipids	4	4
	II	Carbohydrates, vitamins and minerals		4
	III	Enzymology		4
	IV	Thermodynamics and Electron Transport Chain		4
Paper IV	**Biostatistics and Instrumentation**			
PSLSC104	I	Biostatistics I	4	4
	II	Biostatistics II		4
	III	Instrumentation I		4
	IV	Instrumentation II		4

SEMESTER II

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	L / WEEK
Paper I	**Microbiology, Immunology and Plant Physiology**			
PSLSCT201	I	Microbiology	4	4
	II	Immunology		4
	III	Plant physiology I		4
	IV	Plant physiology II		4
Paper II	**Molecular Biology and Cell signaling**			
PSLSC202	I	Gene and Epigenetics	4	4
	II	Gene Expression Regulation		4
	III	Essentials of Gene cloning		4
	IV	Cell communication and signalling		4
Paper III	**Animal Science**			
PSLSC203	I	Animal Physiology	4	4
	II	Developmental Biology		4
	III	Neurobiology		4
	IV	Endocrinology		4
Paper IV	**Bioinformatics, IPR and Bioethics**			
PSLSC204	I	Bioinformatics	4	4
	II	Alignment problem and solutions		4
	III	Genomics and Proteomics		4
	IV	IPR and Bioethics		4

SEMESTER I

PAPER - PSLSCT101: Environmental Biology, Evolution, Genetics

Prerequisites: Students should have basic knowledge of ecology, genetics and molecular biology.

Course Objectives:

- To discuss
  - various aspects of ecology
  - Inter-relationship between diverse organisms
  - The molecular basis of inheritance.

Course Outcome:

On completion of the course, learner will be able to

- Acquire skills in genetic analysis.
- Match the relationship between ecosystem and the individual.
- Explore the correlation between organisms and their evolution.

Unit I: Environmental biology (15L)

Ecosystems: Concept, structure, function and dynamics of ecosystem, components, ecological succession; Habitat and niche, Food web and energy flow, productivity and biogeochemical cycles, Types of ecosystems (terrestrial (forest, grassland) and aquatic (fresh water, marine, eustarine), ecosystem modelling and resource management and conservation.

Community ecology: Nature of communities; community structure and attributes; levels of species diversity and its measurement; edges and ecotones.

Population ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (*r* and *K* selection); concept of metapopulation – demes and dispersal.

Renewable energy and biofuels

Environmental health: Environmental stress and adaptation, effects of pollution on living systems, environmental pollutants related human disorders, biomonitoring indicators, bioremediation of pollutants. Climate change

Toxicology: Basic principles of toxicology including LD_{50} and ED_{50}, management of acute intoxication, Biochemical and Genetic mechanism of natural detoxification.

Unit II: Biodiversity (15L)

Biodiversity: Concept, characterization, generation, maintenance and loss, Magnitude and distribution of biodiversity, economic value, bioprospecting, biodiversity managementapproaches.

Species interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.

Conservation biology: Principles of conservation, major approaches to management, conservation strategies and cryopreservation.

Genetically modified organisms (GMOs): Definition of GMOs, applications in food and agriculture, Release of GMO in environment – risk analysis, risk assessment and risk management, Identification of GMO in environment and their impact, emergence of

drugs/ pesticide/ herbicide resistance and diseaseburden.

Unit III: Evolution (15L)

Emergence of evolutionary thoughts: Lamarck; Darwin–concepts of variation, adaptation, struggle, fitness and natural selection; speciation; Mendelism; spontaneity of mutations; the evolutionary synthesis.

Origin of cells and unicellular evolution: Origin of basic biological molecules; abiotic synthesis of organic monomers and polymers; concept of Oparin and Haldane; experiment of Miller (1953); the first cell; evolution of prokaryotes; originof eukaryotic cells; evolution of unicellular eukaryotes; anaerobic metabolism, photosynthesis and aerobic metabolism.

Paleontology and evolutionary history: The evolutionary time scale; eras, periods and epoch; major events in the evolutionary time scale; origins of unicellular and multicellular organisms; major groups of plants and animals; stages in primate evolution includingHomo.

Molecular Evolution: Concepts of neutral evolution, molecular divergence and molecular clocks; origin of new genes and proteins; gene duplication and divergence, molecular taxonomy.

Unit IV: Genetics (15L)

Extensions of Mendelian principles: Codominance, incomplete dominance, Multiple alleles, Lethal and Essential Genes.

Non Mendelian Inheritance: Cytoplasmic inheritance, organelle genetics, maternal inheritance.

Microbial genetics: transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating.

Quantitative genetics: Pleiotropy and epitasis, polygenic inheritance, heritability and its measurements, QTL mapping, linkage and crossing over.

Population Genetics: gene pool, gene frequency, Hardy Weinberg Law and its role in evolution and speciation, Pedigree analysis.

Gene mapping methods: Linkage maps and lod score for linkage testing, tetrad analysis, mapping with molecular markers, mapping by using somatic cell hybrids, development of mapping population in plants.

Human Genome Project and Genome wide associated studies.

PRACTICALS: PSLSCP 101

1. Study of animalinteraction:
   a. Commensalism: Hermit crab and sea anemone, Echinus and shark (or any otherexample).
   b. Mutualism: Termite and Trichonympha (or any other example).
   c. Antibiosis: Effect of antibiotic on bacterial growth on a petri plate (or anyother example).
   d. Parasitism: Ectoparasite – head louse and bed bug (or any otherexample).
   e. Endoparasite: Trichinellaspiralis (or any otherexample).
   f. Predation: Praying mantis and spider (or any otherexample).
2. Determinationofpopulationdensity(Daphniaoranysuitableorganism) bysubsampling method.
3. Comparison of two population of a species collected from twoareas.
4. Effect of toxicity in water on*Daphnia.*
5. Production/ Extraction of biofuel from plantsource.

6. Problems in Genetics
    a. Problem solving: Multiple alleles, Lethalgenes
    b. Problem solving: Hardy Weinberg equation, Pedigreeanalysis.
7. Transformation of *E .coli*cells.

References:

- The Cambridge Encyclopedia of Human Evolution (Cambridge Reference Book) by Steve Jones
- Evolution by Monroe W. Strickberger, CBS publishers anddistributors
- Biodiversity, Wilson E.O. (Ed.), National Academy Press, Washigton, D. C.
- Understanding Biodiversity by David Zeigler (May 30, 2007): AmazonPress
- Fundamentals of Ecology by E.P. Odum, Cengagepublishers
- Ecology and environment by P.D. Sharma, Rastogipublications
- Elements of Ecology by Smith and Smith, Pearsonpublishers
- Environmental Biology edited by Mike Calver*et al*: Cambridge UniversityPress
- Molecular Environmental Biology by Seymour J. Garte, Lewis Publishers (1994):256pp
- Basic Environmental Toxicology, Lorris G. Cockerham& Barbara S. Shane, CRCPress.
- David Wright and Pamela Welbourn, Environmental Toxicology, Cambridge university press
- Principles of Genetics-Tamarin
- Microbial Genetics- Freifelder
- iGenetics-Russell
- Genetics- BenjaminPierce
- Introduction to Genetics- T.A.Brown

PAPER - PSLSCT102: Cell and Molecular Biology

Prerequisites: Students should have basic knowledge of Molecular biology, Plant and Animal Cell structure.

Course Objectives:

- To elaborate on cell structure, components and their function.
- To distinguish between the molecular aspects of cell cycle and cell death.
- To compare the various basic molecular processes of the central dogma of life.

Course Outcome:

On completion of the course, learner will be able to

- Describe the detailed structure of the cell and correlate with its functions.
- Draw inferences from the molecular aspects of the cell life cycle.
- Articulate the differences between the nuclear and cellular processes.

Unit I: Cell Biology (15L)

Plasma membrane: Different model membrane and their structures, lipid bilayer. **Endoplasmic reticulum:** RER and SER, synthesis and transport of protein into the lumen of the ER and its control. Oil bodies and protein bodies inplants.
Golgi complex: Cisternal progression, secretory pathway – transport to the plasma membrane and the extracellular space.
Nucleus: including nuclear pore, lamins, chromatin.
Other organelles: Lysosomes, peroxisomes, mitochondria, chloroplasts and vacuoles.
Cytoskeleton: Filaments and concept of cellular architecture and motility.

Unit II: Cell cycle and Cell Death: (15L)

Molecular events in the various cell cycle stages (without experimental details).

Introduction: Stages of the cell cycle – G0, G1, S, G2 and M.

Concept of cyclin and CDKs; activation of the cyclin-CDK complexes.

G1 cyclins: Cln1, Cln2 and Cln3 and its relevance in commitment to cell division.

S phase and G2 phase: S phase cyclin, its inhibitors and pre-replication complex and its significance in DNA replication in the cell cycle.

M phase: Prophase, Metaphase, Anaphase and Telophase, condensins, securin, separase and the end of mitosis.

Apoptosis: Concept of programmed cell death, Comparison with necrosis, Function of apoptosis in development and maintenance (formation of digits, removal of old cells etc.).

Unit III: Basics of Life processes I (15L)

DNA replication: Unit of replication and enzymes, replication origin and replication fork, fidelity and processivityof replication, extrachromosomal replicons(plasmid).
DNA repair: Direct repair, Excision of base pair, Post replicative, SOS.
Recombination: Homologous and Non Homologous.

Unit IV: Basics of Life processes II (15L)

Transcription: Classes of RNA molecules - structure and function.
Basic features of RNA synthesis: Transcription factors and machinery.
Transcription in prokaryotes: *E. coli* RNA polymerase, transcription activators and repressors, initiation, elongation and termination, processing of tRNA and rRNA in *E. coli*.

Transcription in Eukaryotes - formation of initiation complex, capping, elongation & termination, RNA processing, RNA editing, major and minor splicing systems, polyadenylation, Eukaryotic rRNA genes, formation of eukaryotic tRNA molecules,
RNA Polymerases of eukaryotes, RNA polymerase II Promoters, Eukaryotic Promoters for RNA polymerase III, Hypersensitive sites, Upstream activation sites and enhancers. **Translation**: Outline of Translation.
The Genetic Code: The Decoding System, Codon -Anticodon interaction.
Ribosomes: the special properties of the prokaryotic and eukaryotic ribosomes, ribosome biogenesis.
Translation process: initiation, elongation and termination factors of prokaryotes and eukaryotes mechanisms to overcome premature translation termination, role of suppressor tRNAs.
Inhibitors of protein synthesis: Prokaryotic and eukaryotic protein synthesis inhibitors and their significance.

PRACTICALS: PSLSCP102

1. Electron Micrographs of cell organelles; Fluorescent stained histochemically localized cytoskeleton elements.
2. Isolation of chloroplasts from spinach (or any other suitable system) and chlorophyll estimation.
3. Onion root tip squash/ preparation for stages of mitosis.
4. Isolation of RNA from a suitable system and estimation (orcinol reagent).
5. PCR amplification of 16s rRNA.

Reference:

- Principles of Biochemistry- Lehninger, Nelson and Cox
- Gene VIII- Lewin
- Principles of Genetics- Tamarin
- Microbial Genetics- Freifelder
- iGenetics- Russell
- Genetics- Benjamin Pierce
- Introduction to Genetics- T.A. Brown
- Molecular Cell biology: 5th Edition and above. Harvey Lodish, Arnold Berk, S Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James Darnell

PAPER - PSLSCT103:Biochemistry
Prerequisites: Students should have basic knowledge of Biochemistry.

Course Objectives:

- To discuss
    - Biomolecular structure and function
    - Enzyme kinetics and regulation
    - Thermodynamics in biology with a reference to electron transport chains.

Course Outcome:
On completion of the course, learner will be able to

- Elaborate on the structure and functions of non-nucleic biopolymers.
- Characterize enzymes based on kinetics and regulation.
- Interpret the outcomes of reactions based on thermodynamic principles.

Unit I: Protein and Lipids(15L)

Protein: Primary structure elucidation, secondary structure structures eg. Keratin, Collagen, tertiary structure and the underlying interactions/ forces, quaternary structure and with references to haemoglobin, protein folding, domains and motifs, cytoskeltal and extracellular proteins.

Lipids: structure, classification and properties of lipids, lipid assembly, model membranes, formation of liposomes and drug targeting.

Unit II: Carbohydrates, Vitamins, Minerals (15L)

Carbohydrate: Classification and stereochemistry, structure, properties and biological roles of storage and structural polysaccharides such as, starch, glycogen cellulose, pectin, hemicelluloses, chitin, mucopolysaccharides. Biosynthesis and role of N and O- linked glycoprotiens and proteoglycans.

Vitamins: Structure and biological roles of water soluble and lipid soluble vitamins.

Minerals: Structure and biological roles of bulk and trace elements

Unit III: Enzymology (15L)

Enzyme: enzyme and enzyme substrate interactions, chemical modification, and identification of active site amino acids, mechanism of enzyme catalysis with reference to chymotrypsin, lysozymes, metalloenzymes and the role of metals in catalysis with reference to carboxypeptidase.

Regulation: regulation of enzyme action, theory of allostery with reference to AT case, Isozymes with reference to LDH: Co-enzymes and their roles, enzyme inhibitors, types and their kinetics, ribozymes and abzymes.

Unit IV: Thermodynamics and Electron Transport Chain (15L)
Thermodynamics: The laws of thermodynamics, enthalpy, entropy and free energy concepts and their relevance to biological systems.

ET: electron transport chain (ETC) and oxidative/photophosphorylation: structure and function of mitochondrial and chloroplast ETC proteins and light harvesting complex, mechanism of oxidative and photophosphorylation, F_0 F_1 ATPase, theories of ATP synthesis.

PRACTICALS: PSLSCP103

1. Estimation of sugar by DNSAmethod.
2. Enzyme kinetics, effects of pH, temperature, time and substrate concentration, determination of Km and Vmax using potatophosphatase/Amylase.
3. Estimation of protein by FolinLowry
4. Lipid extraction and estimation by Bligh and Dyermethod.
5. Estimation of ascorbic acid from vegetable source by colorimetricmethod.
6. Determination of phosphorous by Fiske-Subbaraomethod.

References

Name :Principle of Biochemistry
Author :Lehninger, Albert L. (III Ed. 2000 worth pub)
Publisher :CBs publishers and distributors

Name :Biochemistry
Author :Stryer, Lubert
Publisher :W. H. Freeman

Name :Student's companion for Stryer's biochemistry
Author :Gumport, Richard I, Jonas, Ana, Mintel, Richard, Rhodes,Carl
Publisher :W. H. Freeman

Name :Biochemistry and Molecular biology
Author :Elliott, Willam H, Elliott, Daphne C
Publisher :Oxford University Press

Name :Oxford dictionary of biochemistry and molecular biology
Publisher :Oxford University Press

Name :Proteins- Structures and molecular properties
Author :Creighton, T. E
Publisher :Freeman and Co

Name :Biochemistry of cell membranes: a compendium of selected topics
Author :Papa S., ed. Tager, J. M., ed
Publisher :BirkhauserVerlag

Name :Membrane protein models
Author :Findlay, J. B. C., ed
Publisher :IOS scientific publishers

PAPER - PSLSCT104: Biostatistics and Instrumentation

Prerequisites: Students should have basic knowledge of statistics and laboratory instruments.

Course Objectives:

- To design experiments that support analysis using statistics.
- To study the population dynamics through statistical measures.
- To expose the students to the advanced instrumental technologies currently used in biology.

Course Outcome:

On completion of the course, learner will be able to

- Appraise the significance of experimental data generated in biology.
- Document population parameters in a biological system.
- Operate and predict the analytical scope of the laboratory instruments.
- Attain clarity on the principles and applications of advanced laboratory instruments.

Unit I: Biostatistics I (15L)

Introduction: Introduction, scope, application and uses of statistics, collection and classification of data, census and sampling, graphs and diagrams, arithmetic mean, median, standard deviation.
Correlation and regression: for ungrouped data, scatter diagram, calculation and interagtion of correlation coefficient, linear regression coefficient and equation of the lines of regression, non-linear relationship transformable to linear form ($Y=ab^X$, $Y=a^xb$). **Probability**: definition, addition and multiplicative laws (without proof). Random variable and its distribution, binomial probability distribution, examples and conditions, means and variance, poisson probability distribution, examples and conditions, means and variance, continuous variable, normal distribution, use of normal probability table for findingprobabilities.
Population Statistics: Population parameters and sample statistics, sampling techniques, simple random sampling, stratified random sampling, systematic sampling, standard error of mean. Estimation, point and interval, confidence interval for population, mean and proportion.

Unit II: Biostatistics II (15L)

Hypothesis testing: type-1 and typr-2 errors, levels of significance, one tailed and 2 tailed tests, application to single mean and single proportion, equality of two population means and two populationproportions.
Chi-test: for independent attributes in rxc table, special case 2x2 table.
Students test for significance for correlation, coefficient r for P=0 (small sample tests). Fishers Z transformation coefficient for getting rp=0 in large samples, test of significance for r (p=0).
Design of experiment: principles and concepts of completely randomised design, randomized block design and Latin square design.
Variance ratio F tests: analysis of variance in one way classification.
Non-parametric tests: distribution free methods, sign test for method pairs, Willcoxon test for unpaired data, run test.

Unit III: Instrumentation I (15L)

pH, Buffers and colorimetry: Principles and theory, pH meters.
Colorimetry and spectroscopy: Basic principles, nature of electromagnetic radiation, Beer-Lambert laws, colorimetric methods and instruments, principlesof spectroscopy,types of spectra-absorbance, emission, fluorescence and action spectra, single and double beam spectrophotometers, densitometers, circular dichroism and their applications.

Microscopy: Basic principles, instrumentation, sample preparation for optical, phase- contrast, interference, polarisation, inverted, fluorescence, confocal and electron microscopes and their applications.
Microtomy: Principles and types, sample preparation and sectioning parameters.
Centrifugation: Principles and types, simple and differential, ultracentrifugation – preparative and analytical.

Unit IV: Instrumentation II (15L)

Chromatography: Principle, methodology and applications of chromatography using (paper, thin layer, column(gel filtration, ion exchange, affinity, gas, HPLC,FPLC etc).
Electrophoresis: Principles and types of electrophoresis and their applications for proteins, nucleic acids, including gradient gel and pulse-field gel electrophoresis, gel matrices-polyacrylamide, agaroseetc, critical parameters for optimum separation and resolution , two dimensional electrophoresis(IEF).
X-ray crystallography, Nuclear Magnetic Resonance (NMR) spectra, Magnetic Resonance Imaging (MRI – fMRI) lasers in biology and medicines.
Radioisotope methods and tracer techniques in biology: Basic principles of radioactivity, properties and handling of radioisotopes in biology and medicine, radiation units, Geiger- Muller and scintillation counters, autoradiography, radionucleide imaging, CT Scan and PET scan
Techniques: Histology, ELISA, RIA, Immunoprecipitation - single and double, Primers, PCR and its types, RFLP, RAPD, AFLP, Blotting techniques: Southern, Western and Northern, In-situ Hybridization: FISH, GISH SKY, Chromosome Painting

PRACTICALS: PSLSCP104

1. Preparation of Phosphate, Tris, citrate buffers of variousmolarity.
2. Determination of lambda max of $KMnO_4$, $CoCl_2$, methylene blue byspectrophotometer.
3. Verification of Beer-lamberts law by UV Visiblespectrophotometer
4. Separation of amino acids by paperchromatography.
5. Separation of lipids byTLC.
6. Solving problems using Students t Test, ANOVA and Regressionanalysis.
7.

References:

- Practical biochemistry – Principles and Techniques- Wilson K and WalkerJ
- Essentials of Biophysics- NarayananP.
- Analytical Techniques in Biochemistry and Molecular Biology by RajanKatoch,
- Modern Analytical Biochemistry; Rodney Boyer (3rdEdition)
- Principles of Instrumental Analysis:Skoog

- Methods in Biostatistics- Mahajan P.K

SEMESTER - II

PAPER - PSLSCT201: Microbiology, Immunology and PlantPhysiology

Prerequisites: Students should have basic knowledge of microorganisms, plants and common human diseases.

Course Objectives:

- To discuss in depth concepts of:
  - Microbiology
  - Immunology
  - Plant physiology.

Course Outcome:

On completion of the course, learner will be able to

- Identify microbes and correlate the effect of host-parasite relationships and its treatment.
- Extend the immunological concepts and its application in medical field.
- Extrapolate the basic plant physiology principles to modern observations.

Unit I: Microbiology(15L)

Microbial diversity: Bacteria, Archaea and their Outline of classification; Eukaryotic microbes: Yeasts, molds and protozoa; Viruses and their classification; Molecular approaches to microbial taxonomy. Bacteria: Purple and green bacteria, budding bacteria rods, Spirochaetes, Sheathed bacteria, Endospore forming rods and cocci. Archaea: Archaea as earliest life forms; halophiles, Methanogens; Hyperthermophilicarchaea and Thermoplasma. Eukarya: Algae, Fungi, Slime molds- General characteristic and types.

Prokaryotic Cell Structure- Cell wall, cell membrane synthesis and nucleoid; Flagella and motility; cell inclusions like endospores, gas vesicles.

Microbial Growth: Growth curve; Mathematical expression of exponential growth phase; Measurement of growth and growth yields; Synchronous growth; Continuous culture; Effect of environmental factors on growth; diauxic growth.

Chemotherapy/Antibiotics: General characteristics of antimicrobial drugs; Antibiotics: Classification, mode of action and resistance; Antifungal and antiviral drugs.

Host Parasite Interaction: Recognition, mechanism of microbial pathogenicity and establishment of disease by different pathogens like viruses, bacteria and parasites into animal hosts (one example each). Nosocomial infection; Emerging infectious diseases; alteration of host cell behavior by pathogens.

Unit II: Immunology: (15L)

Lymphatic system, structure and function of spleen and lymph node.

Major Histocompatiility Complex I and II and their importance.

B cells: Development, generation of antibody diversity, activation somatic hypermutation and class switch. Primary and secondary immune modulation

T cells: Development, TCR diversity, selection and types of T cells and activation.

The Complement and its regulation.

Immune response to infectious diseases: Viral, Bacterial, Parasitic, AIDS.

Congenital immunodeficiencies: SCID.

Autoimmune diseases - Myasthenia gravis, Rheumatoid arthritis.
Applied Immunology: Monoclonal antibodies, scFv, Chimeric antibodies, bispecific antibodies, phage display, Recombinant and polyvalent vaccines.

Unit III: Plant Physiology I: (15L)

The plant Cell wall: Architecture, composition and biosynthesis.
Transportation: Materials through xylem, phloem and plasmodesmata.
Nitrogen metabolism: Symbiotic nitrogen fixation, Ammonia and nitrate uptake and metabolism
Plant Hormones: Biosynthesis and biological activity of auxins, cytokinins, gibberellins, Ethylene, Abscissic acid, Salicylates, Jasmonates and Brassinosteroids.
Sensory Photobiology: Cryptochromes, phototropins; photoperiodism and biological clocks.
Plant Development: Phytochromes and its role in plant development including flowering, germination of pollen and self incompatibility, Double fertilization and seed formation (one typical example ofeach).

Unit IV: Plant physiology II: (15L)

Seed germination: The hormonal and nutritional aspect of seed germination. **Root and Shoot:** Development, organization of root and shoot apical meristems. **Leaf: Development** and phyllotaxy, stomatal movement.
Flower development: Floral organogenesis and the genes Involved:Examples*Arabidopsis* and *Antirrhinum*.
Programmed Cell Death and Senescence in plants: Concept, effect on pigments in plants, environmental factors and hormonal factors.
Stress response: Plant response to abiotic stress- Water, salt and temperature.
Response and resistance to biotic stress (viral, fungal and insects): Host recognition and establishment of disease, overview of plant defense methods (anatomical, secondary metabolites, hypersensitive reactions, hormonal signals and the *R - avr*system).

PRACTICALS: PSLSCP201

1. Diauxic growth curve.
2. Antimicrobial activity by agar cup/ disc method.
3. Sandwich ELISA. (Demonstration)
4. Semi-quantitative Mancinitest.
5. Proline content in normal and saline stressedplants.
6. Effect of Salinity on seedviability.
7. Estimation of Indole AceticAcid.
8. Study of the organization of apical meristems: root andshoot.
9. Examples of phyllotaxy: spiral, opposite decussate, whorled.
10. Flower aestivation: valvate, imbricate, twisted and pappilionaceous type.

References:

- Text book of microbiology: Ananthanarayan and Paniker; Orientblackswan
- Microbiology: Prescot andDunn
- Biochemistry and Molecular Biology of Plants: Bob Buchanan (Editor), WilhelmGruissem(Editor) and RusselJones.
- Plant Physiology 3rd Edition:Taiz andZeiger.
- Plant Physiology and Development, 6th Edition: Taiz andZeiger.
- Immunology 5th Edition, Janis Kuby; OR Kuby Immunology 7th Edition: Judy Owen (*Haverford College*) , Jenni Punt (*Haverford College*) , Sharon Stranford (*Mount Holyoke College*)

PAPER - PSLSCT202: Molecular Biology and Cell signaling.

Prerequisites: Students should have basic knowledge of Molecular Biology and Biochemistry.

Course Objectives:

- To study regulation of genes by epigenetics.
- To differentiate between various prokaryotic and eukaryotic genes regulation processes.
- To elaborate on basic techniques of genetic engineering.
- To explain the cell-cell communication.

Course Outcome:

On completion of the course, learner will be able to

- Associate changes in chromosome structure with protein expression levels.
- Explain the effect of gene modulation process on gene expression.
- Extrapolate the genetic engineering techniques to create genetically modified organisms.
- Portray biochemical communications between the cells.

Unit 1: Gene and Epigenetics: (15L)

Structure of Gene: Monocistronic and Polycistronic, Promoter, Operator, ORF, Terminator, Gene families, Pseudogenes, Split Gene.

Other elements of Eukaryotic Genome: Satellite DNA, Tandem repeat array, Transposons: LINE and SINE.

Genomic Mutations: Introduction, Deletions, Addition, Insertion, Inversions and Translocations.

Chromatin Structure: Histones, Non-Histones, Scaffolding proteins.

Epigenetics: Hypothesis, Imprinting, Mechanism (Methylation and Acetylation), Cancer genetics, Anticipation, Penetrance and Expressivity.

Unit 2: Gene Expression Regulation: (15L)

Regulation of Gene expression in Prokaryotes: General aspects of Regulation, transcriptional regulation - inducible and repressible system, positive regulation and negative regulation; Operon concept – lac, trp, Ara operons, the galactose operon, relative positions of Promoters and Operators, Regulons, Master switches, Regulation of Translation, Regulation of the synthesis of Ribosomes, Unregulated changes in gene expression, Feedback Inhibition, RNA interference, mRNA half-life, riboswitches, ribozymes.

Gene expression in Eukaryotes: Regulatory strategies in Eukaryotes, Transcriptional Control by hormones, signalling factors and environmental factors, Role of transcription factors, enhancers, silencers, chromatin remodelling in regulation of gene expression, role of post-translational modifications in transcription initiation, Regulation of processing, Regulation through RNA splicing, RNA degradation and RNA interference, Translational control, Regulation of gene expression in plant cells by light. Diseases associated with defects in regulation

Unit 3: Essentials of Gene cloning (15L)

Clone: Importance of DNA Cloning, Principles of Cell-based DNA Cloning and cell independent DNA cloning, Cutting and Joining DNA methods,

Vectors: Essential components of vectors and their significance, Plasmid vectors, Vectors based on the lambda Bacteriophage, Cosmids, M13 vectors, expression vectors, YACs and BACs. Use of *Agrobacterium tumefaciens*and A. *rhizogenes*, Direct DNA transfer to plants, Use of plant

viruses as episomal expression vectors. Production of transgenic mice, ES cells can be used for gene targeting in mice. Gene and cDNA libraries.Use of liposomes, transfection, biolistics, adenovirus, microinjection, electroporation, transformation, transduction, and protoplasts for gene transfer in eukaryotic and prokaryoticcells.

Unit 4: Cell communication and signalling: (15L)

Concept of cell surface receptors, second messengers and regulation of the signalling pathway.

Signalling pathways: (a). Receptor tyrosine kinases (RTK): EGF signalling leading to cell division. (b). JAK-STAT pathway. (c). G protein coupled receptors. (d). Bacteriorhodopsinsignalling. (e). Toll-like receptors (in immunology).
Two component signalling: (a). Bacterial – chemotaxis, quorum sensing. (b). Plant two component signalling.
Extracellular matrix: Fibres, cell adhesion molecules and their functions, gap junctions.
Cancer: As an aberration of the cell cycle; oncogenes, virus induced cell transformation, metastasis and treatment.
Cell Death: Apoptosis (extrinsic and intrinsic) signalling pathways, effects of aberrant apoptosis.

PRACTICALS: PSLSCP 202

1. Isolation of plasmid from *E.coli.*
2. Induction of the Lac operon and assessment of enzyme activity using a suitable system (e.g. *E.coli*).
3. Isolation of histone from yeast cells.
4. FISH (Demonstration).
5. Assessment of signalling pathways (PKC, $IP_3$and Calcium) in the regulation of nitrate assimilation in plants/bacteria.

References:

- Principles of Biochemistry- Lehninger, Nelson andCox
- Gene VIII-Lewin
- Principles of Genetics-Tamarin
- Microbial Genetics-Freifelder
- iGenetics-Russell
- Genetics- BenjaminPierce
- Introduction to Genetics- T.A.Brown
- Molecular Cell biology: 5^{th} Edition and above. Harvey Lodish, Arnold Berk, S Lawrence Zipursky, Paul Matsudaira, David Baltimore, and JamesDarnell

PAPER - PSLSC203: Animal Science

Prerequisites: Students should have basic knowledge of zoology.

Course Objectives:

- To study.
  - Animal physiology
  - Development and Morphogenesis
  - Neurobiology
  - Hormonal controls in animals.

Course Outcome:

On completion of the course, learner will be able to

- Outline various aspects of physiological systems.
- Visualize details of embryology, organogenesis and morphogenesis.
- Illustrate the activation of the nerves and their effects.
- Relate the hormones with their biological functions.

Unit I: Animal Physiology (15L)

Blood: Blood corpuscles, haemopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin, immunity, haemostasis.
Cardiovascular System: Comparative anatomy of heart structure, cardiac cycle, blood pressure, neural and chemical regulation.
Physiological Systems: Respiratory system, Digestive system, Excretory system
Thermoregulation: Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization.
Osmoregulation, Stress and adaptation Unit

II: Developmental biology (15L)

Concepts of development: Brief history of developmental biology, Potency, commitment, specification, induction, competence, determination and differentiation;
Gametogenesis, fertilization and early development: Production of gametes, cell surface molecules in sperm-egg recognition in animals; zygote formation, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals
Morphogenesis and organogenesis: axes and pattern formation in *Drosophila*; Vertebrate eye lens induction; limb development and regeneration in vertebrates; Differentiation of neurons; metamorphosis;

Unit III: Neurobiology (15L)

Overview: central nervous system (CNS) and peripheral nervous system (PNS)- structure, organization and function
Cellular perspective: types of cells and function
Impulse generation and conduction of nerve impulse
Synaptic transmission: Electrical and Chemical with examples of two neurotransmitters and their receptors; cAMP as messenger, Neuromuscular junctions – structure and function.

Sensory systems: Visual, Auditory, Chemosensory, Somatosensory
Motor systems – Overview of motor circuits and neural control.
Behavior– Reflexive behavior and homeostasis, Associative and non-associative memory.

Unit IV: Endocrinology (15L)

Endocrine system: Structure and functions of Endocrine glands, Structure, biological roles and mechanism of actions of hormones (protein, glycoprotein and steroid hormones).

PRACTICALS: PSLSCP203

1. Mounting of cornea and statocyst ofprawn.
2. Chick embryology- FreshMounting.
3. Neutral red staining for apoptosis in developing chickembryo.
4. Permanent slides of different stages of chick embryo.
5. Microtomy- sections of chick liver and histopathologicalstudy.
6. Permanent slides of tissues.
7. Study of ECG inhumans.
8. Study of EEG inhumans.

References:

- Principles of Development: L. Wolpert, R. Beddington, J. Brockes, T. Jesell and P. Lawrence. Oxford UniversityPress
- Developmental Biology: W.A. MillerSpringer –Verlag.
- Developmental Biology: S.F. Gilbert. Sinauer Associates Inc. Publishers (4th edition).
- An Introduction to Embryology: B. I. Ballinsky' Saunders, College Publishing Co. 4th Ed.
- Molecular Biology of the Cell: Bruce Alberts, Alexander Johnson, Julian Lewis , David Morgan , Martin Raff, Keith Roberts, Peter Walter 5th Edition (2007) or 6th Edition (2014). Pub: GarlandScience
- Neuroscience: D. Purves, G. Augustine, D Fitzpatrick, W. Hall, A. LaMantia, L. White.Sinauer Associate Inc (2012) 5th edition.
- Principles of Neural Science: E. R. Kandel, J.H.Schwartz and T.M. Jessel.Prentice Hall Internation.(2012)
- Neuroscience: Exploting the brain M. F. Baer, B.W.Connors& M. A. Paradiso, William & Wilkins,Baltimore
- Text Book of Medical Physiology: A. C. Guyton and J.E.HallSaunders College Publishers.
- Principles of Anatomy and Physiology:G. Tortoraand S.Grabowski John Wiley & Sons, Inc. 10th edition.
- Fundamentals of Neurobiology: Shepherd G M 3rd Edition, Oxford UniversityPress.
- Elements of Molecular Neurobiology: C.U.M. Smith, Wiley and sonsPublication.
- Text Book of Medical Physiology: Guyton andHall
- Text Book of Biochemistry and Human Biology: Talwar and Srivastava (3rdEdison)
- Developmental Biology: Mohan andArora.

PAPER - PSLSCT204: Bioinformatics, IPR and Bioethics

Prerequisites: Students should have basic knowledge of Molecular Biology.

Course Objectives:

- To acquire knowledge on generation of databases and data mining.
- To generate alignments of gene and protein sequences.
- To explore the use of technology to understand genome and protein biology.
- To discuss importance of IPR and ethics in biology.

Course Outcome:

On completion of the course, learner will be able to

- Capture the essence of bioinformatics.
- Handle and analyze biological sequences.
- Design and evaluate the biological experimental systems using bioinformatics tools.
- Combine and relate the concepts of IPR and ethics in biology.

Unit I: Bioinformatics (15L)

Introduction to Bioinformatics: Definition and History of Bioinformatics, Different Omics and its application and Current status.
Computers and Internet: Operating systems, Internet and its components, Internet sources for Bioinformatics, Flat file.
Introduction to Data Mining: Types of Data, Data mining and warehousing, Knowledge discovery indatabases
Biological databases: Primary DNA and Protein Databases, Secondary Protein Databases, Secondary Composite Structure Databases, Protein Databank (PDB), Metabolism Database (KEGG).

Unit II: Alignment problem and solutions (15L)

Multiple Sequence Alignment (MSA): Definition, Objective, Consensus, Methods for MSA: Heuristic approach, Dynamic programming approach and their combinations.
Pairwise Alignment: Introduction, PAM Matrix, BLOSUM Matrix, The Dot Plot, Global alignment, Local alignment, FastA and BLAST. Statistics: P and Evalue.
Phylogenetic Analysis: Molecular-Phylogenetics, Phylogenetic-trees, Terminology of tree-reconstruction, rooted and un-rooted trees, gene vs species trees and their properties, Methods: UPGMA, Neighbor-Joining Method, Maximum Parsimony.

Unit III: Genomics and Proteomics (15L)

Genomics: Basic concepts on identification of disease genes, role of bioinformatics-OMIM database, reference genome sequence, integrated genomic maps, gene expression profiling; identification of SNPs, SNP database (DbSNP). Role of SNP in Pharmacogenomics, SNParrays.
Proteomics: Introduction and current status, Prediction of secondary structure: PHD and PSI-PRED method. Tertiary (3-D) Structure prediction: Fundamentals of the methods for 3D structure prediction (sequence similarity/identity of target proteins of known structure, fundamental principles of protein folding etc.) Homology Modeling, fold recognition, threading

approaches, and ab-initio structure prediction methods. Application in drug designing: Drug targets, Lead Identification and Modification, Computer-Aided DrugDesign.

Unit IV: IPR and Bioethics (15L)

IPR: Introduction to IPR; Types of Intellectual property – Patents, Trademarks, 12 Copyrights and related rights; Traditional vs. Novelty; Importance of intellectual property rights in the modern global economic environment, Importance of intellectual property rights in India; IPR and its relevance in biology and environmental sciences; Case studies and agreements - Evolution of GATT and WTO andIPR provisions underTRIPS; Madrid agreement; Hague agreement; WIPO treaties; Budapest treaty; Indian Patent Act (1970).
Patents: Definition, patentable and non-patentable inventions; types of patent application – Ordinary, Conventional, PCT, Divisional, and Patent of addition; Concept of Prior Art; Precautions while patenting - disclosure / non- disclosure; Time frame and cost; Patent databases, Searching International databases; Patent licensing and agreement; Patent infringement – meaning, scope, litigation, casestudies.
Bioethics: Definition – moral, values, ethics and ethics in biology; Role and importance of ethics in biology; Basic Approaches to Ethics, Bioethics: legal and regulatory issues; Bioethics in healthcare, agriculture, modern biology, biotechnology, animal welfare & right / animals in research, wildlife conservation and management, commercialism in scientific research, Past and Present 'Bioethical Conflicts' in Biotechnology- Interference with Nature , Fear of Unknown, Regulatory Concerns, Human Misuse Future 'Bioethical Conflicts' in Biotechnology - Changing perception of Nature, Human Genetic Engineering,GMOs.

PRACTICALS: PSLSCP204

1. Multiple sequence alignment and Phylogenetic treeanalysis
2. BLAST- BLASTn, BLASTp, primerBLAST.
3. Motif Finding- MEME andmyhits
4. Secondary Structure Prediction:Interproscan
5. CATH andSCOP
6. KEGG
7. Tertiary Structure: PDB,Rasmol
8. Homology Modeling –SWISS-MODEL

References:

- Introduction to Bioinformatics- Attwood, Parry-Smith andPhukan
- Bioinformatics: Sequence and Genome Analysis- David W.Mount
- Bioinformatics and Functional Genomics- JonathanPevsner
- Fundamentals of Bioinforamtics: HarishaS.
- Bioinformatics and Molecular Evolution: Higgs &Attwood
- Bioinformatics: HarshwardhanPal
- Law Of Intellectual Property Rights-Shiv SahaiSingh
- WTO And Intellectual Property Rights-TalwarSabanna
- IPR: Unleashing the Knowledge Economy- PrabuddhaGangul

OVERALL EXAMINATION AND MARKS DISTRIBUTION PATTERN

SEMESTER I

	COURSE CODE												
Theory	**PSLSCT101**			**PSLSCT102**			**PSLSCT103**			**PSLSCT104**			**GRAND TOTAL**
	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total	
	40	60	100	40	60	100	40	60	100	40	60	100	400
Practicals	**PSLSCP101**			**PSLSCP102**			**PSLSCP103**			**PSLSCP104**			
	-	50	50	-	50	50	-	50	50	-	50	50	200

SEMESTER II

	COURSE CODE												
Theory	**PSLSCT201**			**PSLSCT202**			**PSLSCT203**			**PSLSCT204**			**GRAND TOTAL**
	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total	
	40	60	100	40	60	100	40	60	100	40	60	100	400
Practicals	**PSLSCP201**			**PSLSCP202**			**PSLSCP203**			**PSLSCP204**			
	-	50	50	-	50	50	-	50	50	-	50	50	200