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Item No. _____

UNIVERSITY OF MUMBAI

Program : M. Sc.

Course : Life Sciences

Syllabus for M. Sc. Semester I and II (CBCS)

(with effect from the Academic Year 2021 – 2022) .

CONTENTS

1. PREAMBLE:

Life Science is a subject that encompasses all the fields of life. This branch of Science offers the basic understanding about animals, plants, microorganisms as living resources of Mother Earth and the abiotic factors related to these living beings. Life Sciences also describes the structure & functioning of various physical, physiological, metabolic, biochemical, ecological and socio-economic parameters associated with the functioning of the biotic world. This Course exposes the students to various techniques and technologies used to study life and its multifaceted aspects. It explains the economic and ecological importance of the living beings and the non-living. The course includes animal and plant sciences, microbiology, biochemistry and biophysics, molecular biology and applied genetics, all of which enable the students to strengthen their knowledge in respective branches & understand the scope of the subject as an employment opportunity. The syllabus includes aspects that would inculcate interest in the minds of the students for nature & natural wealth and help them develop skills for observation & analysis of the data gathered, thus preparing them for the future research endeavours.

Students who have completed their B. Sc, in any biological subject or as described in the document - No. PG/ Univ./VCD/ ICC / 2012-13/ 8 (of 19th May 2012) would be eligible to enroll in this programme. Since the academic backgrounds of the learners are diverse, the courses in the first year are designed to allow learners to attain a firm base Life Sciences before they continue their studies in any one of the specializations offered in the second year of the programme.

Semesters I and II of this programme, each have four theory & practical papers. Continuous evaluation has been introduced with the Choice Based Grading System and the learner's academic progress would be monitored throughout the year in the form of Internal Assessment followed by the Term End Assessment.

The program is open to the integration of on-line components in the Syllabus. This component if incorporated, will be kept facultative and with freedom given to the teaching faculty as well as the students to mutually decide the topics for on-line learning. The authorities will decide the final course of action for this dual approach of imparting education & knowledge to the students that breaks the barriers of time, space & infrastructural needs.

2. PROGRAMME OBJECTIVES:

The M. Sc. Life Sciences programme is designed to help the learner to:

1. Acquire basic knowledge of various disciplines of Life Sciences meant for higher studies.
2. Explore and discuss topics in various branches of Life Sciences.
3. Understand the rich diversity of organisms and their ecological, genetic and evolutionary significance, harmony of different life systems and their conservation.
4. Imbibe skills in experimentation, observation and scientific investigation in biology.
5. Increase & improve SIQ (Social Intelligence Quotient) & EQ (Emotional Quotient) and thus become good and responsible citizens in a global sense.
6. Cultivate a self sustainable work ethic and integrate the knowledge gained in future entrepreneurial activities.

3. PROGRAMME OUTCOME

On completion of the course the learner would be able to:

- Apply science & technology in day-to-day activities.
- Discuss and explain subject related concepts and contemporary issues
- Design a project with relevant standards and realistic constraints.
- Describe and explain the structure of an organism and its interaction with the surroundings.
- Articulate and compare concepts in plant, microbial and animal physiology and biotechnology.
- Undertake quantitative and comparative studies on various aspects of biological sciences.
- Acquire knowledge on generation of databases, data mining and alignments of sequences
- Explore the use of technology to understand genome and protein biology.
- Discuss importance of IPR and ethics in biology.
- Attain cross cultural competency by working in teams
- Combine the various concepts in biological techniques and formulate cohesive and socially responsible endeavours.

4. DURATION OF THE COURSE: The P.G. programmes have 4 semesters. There shall be two Semesters in an academic year, the odd semester commences in June-July and on completion, the even Semester commences after a semester-break of one or two days with two months vacation during April and May. However, variations in this theme would be addressed with an academic calendar that would be fixed and declared by the University at the beginning of each academic year.

5. PROGRAMME STRUCTURE:

The programme spans four semesters - Two semesters of 15 weeks (Semester I and II) in the first year and two semesters of 15 weeks (Semester III and IV) in the second year. This programme offers four specializations in the second year namely: Biochemistry, Biotechnology, Environmental Biotechnology and Aquaculture Technology. The learners are required to select

any one of the four specializations that will be taught in the second year (Semester III and IV) of the Masters programme in Life Sciences at the time of admission. However, the syllabus of Semester I and Semester II is common for all specializations that are offered in the Semester III and Semester IV of the programme.
The programme is a Choice Based Credit and Grading System (CBCS). Each credit is of 30 to 40 hours of which 15 hours would be of classroom teaching.

A	Programme Duration	Four Semesters
B	Total Credits required for successful completion of the Course	96
C	Total Credits per semester	24
D	Credits of theory papers	4
E	Credits for Practical Papers	2
F	Minimum Attendance per Semester	75 %

6. EVALUATION:

Theory:

There would be four theory papers for each semester (Semester I and II). The credits earned in each theory paper would be 4. Each theory paper would be of 100 marks. The evaluation of each paper shall contain two parts:

(i) Internal Assessment: 40 marks. (Passing marks: 16)

(ii) External Assessment: 60 marks. (Passing marks: 24)

The external theory examination of all semesters shall be conducted by the University at the end of each semester. Internal evaluation is to be done by continuous assessment.

Internal Assessment: The responsibility of internal assessment shall be vested on the teachers/ group of teachers that teach the paper. The format shall remain flexible and can be in the form of multiple choice questions, case studies, assignments, short answers, presentations, quizzes etc.

External Examination: The rules for registration for the external examination, including attendance, will be as decided by the University of Mumbai. The theory papers shall consist of questions - one devoted to every unit of the paper and one that has questions from all units of the paper. There may be sub-questions for each question and the internal choice in each paper shall be 50%. The maximum marks that can be obtained in the external examination is 60. The University may, under special circumstances, decide an alternative mode of examination.

Practical:

There would be four practical papers of 50 marks each. The credits earned in each practical paper would be 2. Each paper would have 4 lectures per week (60 Lectures in a semester). The learner would be assessed for this component only by an external examination conducted by the University of Mumbai.

References for the courses have been listed at the end of each course. The Faculty may share, in addition, references to reviews and research articles pertinent to the syllabus topics so as to generate a state-of-the-art perspective.

7. CONSOLIDATED SYLLABUS FOR SEMESTERS I & II

SEMESTER I

Course Code	Unit	Topic	Credits	L/Wk
PSLSCT101	**Environmental Biology, Biodiversity, Evolution and Genetics.**		**4**	**4**
	I	Environmental biology		
	II	Biodiversity		
	III	Evolution		
	IV	Genetics		
PSLSCT102	**Cell Biology**		**4**	**4**
	I	Cell Structure and function		
	II	Molecular basis of cell division		
	III	Cell Communication and Immune responses		
	IV	Host microbe interactions		
PSLSCT103	**Plant Physiology:**		**4**	**4**
	I	Plant development and organogenesis		
	II	Material Transport, Photosynthesis and Nitrogen metabolism		
	III	Signalling in plants		
	IV	Stress response		
PSLSCT104	**Biostatistics and Biotechniques**		**4**	**4**
	I	Biostatistics I		
	II	Biostatistics II		
	III	Essentials of Gene cloning		
	IV	Cell and Molecular Techniques		
PSLSCP101	**Environmental Biology, Evolution, Biodiversity and Genetics - Practical**		**2**	**4**
PSLSCP102	**Cell Biology - Practical**		**2**	**4**
PSLSCP103	**Plant Physiology - Practical**		**2**	**4**

PSLSCP104	**Biostatistics and Biotechniques - Practical**	**2**	**4**

SEMESTER II

Course Code	Unit	Topic	Credits	L/Wk
PSLSCT201	**Biochemistry**		**4**	**4**
	I	Carbohydrates, Vitamins, Minerals		
	II	Protein and Lipids		
	III	Enzymology		
	IV	Biochemical Techniques:		
PSLSCT202	**Molecular Biology**		**4**	**4**
	I	Basics of Life processes I.		
	II	Basics of Life processes II.		
	III	Protein Processing and its interactions		
	IV	Regulation of Gene Expression		
PSLSCT203	**Animal Sciences**		**4**	**4**
	I	Animal Physiology		
	II	Developmental biology		
	III	Neurobiology		
	IV	Endocrinology		
PSLSCT204	**Bioinformatics, IPR and Bioethics**		**4**	**4**
	I	Bioinformatics		
	II	Alignment problem and solutions		
	III	Genomics and Proteomics		
	IV	IPR and Bioethics		
PSLSCP201	**Biochemistry - practical**		**2**	**4**
PSLSCP202	**Molecular Biology- practical**		**2**	**4**
PSLSCP203	**Animal Sciences - practical**		**2**	**4**
PSLSCP204	**Bioinformatics, IPR and Bioethics - practical**		**2**	**4**

SEMESTER 1

PSLSCT101: Environmental Biology, Evolution, Biodiversity and Genetics.

Course outcome:

On completion of this course the learner would be able to:

1. Articulate the broad concepts of the environment
2. Explore the diversity and interaction of the biota amongst themselves and with their surroundings.
3. Associate various the various characteristics and trace the evolution of organisms.
4. Review classical theories of inheritance and discover and understand the exceptions.

Unit I: Environmental biology (15 L)

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, estuarine), 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 (15 L)

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

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 disease burden.

Unit III: Evolution (15 L)
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; origin of 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 including Homo.
Molecular Evolution: Concepts of neutral evolution, molecular divergence and molecular clocks; origin of new genes and proteins; gene duplication and divergence, molecular taxonomy- Molecular approaches to microbial taxonomy

Unit IV: Genetics (15 L):
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-general and specialized, mapping genes by interrupted mating.
Quantitative genetics: Pleiotropy and epistasis, 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 (GWAS).

PSLSCP101: Environmental Biology, Evolution, Biodiversity and Genetics – Practical.

1. Study of animal interaction:
   a. Commensalism: Hermit crab and sea anemone, *Echinus* and shark (or any other example).
   b. Mutualism: Termite and *Trichonympha* (or any other example).
   c. Antibiosis: Effect of antibiotic on bacterial growth on a petri plate (or any other example).
   d. Parasitism: Ectoparasite – head louse and bed bug (or any other example).
   e. Endoparasite: *Trichinella spiralis* (or any other example).
   f. Predation: Praying mantis and spider (or any other example).
2. Determination of population density (Daphnia or any suitable organism) by sub sampling method.
3. Comparison of two population of a species collected from two areas.
4. Effect of toxicity in water on *Daphnia.*
5. Production/ Extraction of biofuel from plant source.
6. Problems in Genetics:
   a. Problem solving: Multiple alleles, Lethal genes
   b. Problem solving: Hardy Weinberg equation
   c. Pedigree analysis

References:

1. Steve Jones (1994): The Cambridge Encyclopedia of Human Evolution (Cambridge Reference Book). Cambridge University Press.
2. Monroe W. Strickberger (): Evolution, CBS publishers and distributors
3. Brian K. Hall and Benedikt Hallgrímsson (2013): Strickberger's Evolution. Jones and Bartlett Publishers, Inc.
4. Wilson E.O. (1988): Biodiversity, National Academy Press, Washington, D. C.
5. David Zeigler (2007): Understanding Biodiversity; Amazon Press.
6. E.P. Odum (2005): Fundamentals of Ecology, Cengage publishers
7. P.D. Sharma (2018): Ecology and environment. Rastogi publications
8. Smith and Smith (2015): Elements of Ecology. Pearson publishers
9. Mike Calveret al (2009): Environmental Biology, Cambridge University Press
10. Seymour J. Garte (1994): Molecular Environmental Biology Lewis Publishers
11. Lorris G. Cockerham& Barbara S. Shane, (2019): Basic Environmental Toxicology, CRC Press.
12. David Wright and Pamela Welbourn (2012): Environmental Toxicology, Cambridge University press.
13. Tamarin (1998):Principles of Genetics. Publisher: Brown (William C.) Co ,U.S.

14. Freifelder(1990); Microbial Genetics, Narosa Publishing House
15. Russell (2016): iGenetic. Pearson Education India
16. Benjamin Pierce (2020): Genetics – A conceptual Approach, 7th Edition. Macmillan Publishing.
17. T.A. Brown (2012): Introduction to Genetics. Publisher - Garland Science.

PSLSCT102: Cell Biology

Course outcomes:
The learner would be able to:

1. Review and explore the details of the structure and function of a cell.
2. Explain and compare the steps of cell division and its variations.
3. Capture aspects of cell communication
4. Recognize interactions between cells and their significance.

Unit I: Cell Structure and function (15 L)
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 in plants.
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: Molecular basis of Cell division (15 L)
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.
Control of cell division: Checkpoints of the cell cycle.
Meiosis: A specialized cell division and comparison with mitosis.
Cancer - oncogenes, virus induced cell transformation, metastasis and treatment.
Apoptosis: Concept of programmed cell death, Comparison with necrosis, function of apoptosis in development and maintenance Apoptosis (extrinsic and intrinsic) signalling pathways, effects of aberrant apoptosis.

Unit III: Cell Communication and Immune responses (15 L)
Types of cell signalling: Autocrine, paracrine, endocrine and gap junctions.
Mechanism of Hormone Action: Types of hormones and their action.
Concept of receptors: Cell surface, intracellular and orphan receptors**.**
Second messengers and regulation of the signalling pathway: cAMP, Calcium, IP_3, Feedback regulation (thyroid hormones).

Signalling pathways: (a). Receptor tyrosine kinases (RTK): EGF signalling, JAK-STAT pathway (b). G protein coupled receptors. (c) ion channels -Sodium, potassium (d). Toll-like receptors.
Two component signalling: (a). Bacterial – chemotaxis, quorum sensing. (b). Plant two component signalling. (c). Bacteriorhodopsin signalling.
Extracellular matrix: Fibres, cell adhesion molecules and their functions,
Rearrangement of B cell genome for Antibody production - signalling pathway included
The complement pathway: Classical, Alternate and the MB Lectin pathway.
Immune response to pathogens: The MHC I and II; TB, Malaria, HIV, COVID 19
Congenial and autoimmune disease: SCID, Myasthenia gravis/ Rheumatoid arthritis.

Unit IV: Host microbe interaction (15 L)
Viral interactions: bacteriophages, mimivirus
Beneficial interactions: symbiosis, gut microbiome - composition, secretion of metabolites, effect on human health, diseases associated with gut microbiota, methods of study
Pathogenicity of Microorganisms : Host-parasite relationship, Pathogenesis of viral, bacterial and fungal disease, Host defence against microbial invasion, Microbial mechanisms for its propagation and escaping host defenses - Toxins, invasins, secretion systems, antibiotic resistance genes, modulation of host behaviour, metabolism by pathogens, role of exosomes and pathogen encoded miRNA
The epidemiology of infectious disease : Recognition of an infectious disease and epidemic, Virulence and mode of transmission, Emerging and re-emerging infectious diseases and pathogens, control of epidemics, global travel and health consideration, Nosocomial infections

PSLSCP102: Cell Biology – Practical

1. Antimicrobial activity and Bioautography
2. A study of the MIC of a given extract/ drug using a suitable microorganism.
3. Study of mitosis cell division from onion root tip.
4. Assessment of signalling pathways (PKC, IP_3 and Calcium)
5. Apoptosis: Induction and detection of apoptosis in the yeast system.
6. Micrographs and activity staging of the microstructure of the cell.

References:

1. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter (2002). Molecular biology of the cell 4th edition, Garland Science, New York.

2. Joanne Willey and Kathleen Sandman and Dorothy Wood (2016) Prescott's Microbiology, 10th edition. McGraw Hill Education.
3. Lehninger, Nelson and Cox (): Principles of Biochemistry-
4. Benjamin Lewin (2004): Genes VIII. Publisher - Prentice Hall PTR.
5. Tamarin (1998): Principles of Genetics. Publisher: Brown (William C.) Co, U.S.
6. Freifelder (1990); Microbial Genetics, Narosa Publishing House
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9. T.A. Brown (2012): Introduction to Genetics. Publisher - Garland Science.
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11. Arnold Berk, Chris A. Kaiser, Harvey Lodish et *al*. (2016): Molecular Cell biology: W.H.Freeman & Co Ltd.
12. Janis Kuby (2002):5th Immunology 5th Edition, Publisher; W. H. Freeman.
13. Judy Owen , Jenni Punt, Sharon Stranford (2013): Kuby Immunology 7th Edition. W.H.Freeman & Co Ltd.
14. Cell Biology 3rd edition : Thomas D. Pollard, William C. Earnshaw, Jennifer Lippincott-Schwarts, Graham Johnson
15. Microbiology 7th edition : Prescott and Dunn
16. Andreas Schwiertz (2016): Microbiota of human body - Implications in health and diseases. Springer publication
17. Dirk Haller (2018): The Gut Microbiome in health and diseases. Springer Publication

PSLSCT103: Plant Physiology

Course Outcomes:
The learner would be able to:

1. Trace the stages and control of plant development.
2. Explain important processes typical to plant metabolism.
3. Explore signalling in plants and compare these processes with the animal systems.
4. Review, predict and summarize the plant responses to stress.

Unit I: Plant development and organogenesis (15 L)
The plant Cell wall: Biosynthesis, assembly, growth and differentiation.
Seed germination: The hormonal and nutritional aspect of seed germination.
Root and Shoot: Physiology and regulation of the development, organization of root and shoot apical meristems, tropisms - gravitropism, phototropism, thigmotropism and nastic movements
Leaf: Development and phyllotaxy, stomatal movement.
Flower development: Floral organogenesis and the genes involved: Examples Arabidopsis and Antirrhinum, genetics of pollen germination and self incompatibility,
Programmed Cell Death and Senescence in plants: Concept, effect on pigments in plants, environmental factors and hormonal factors.

Unit II: Material Transport, Photosynthesis and Nitrogen metabolism (15 L)
Source to sink transport and storage: Vacuoles, regulation of transport through xylem, phloem and plasmodesmata.
Photosynthesis: Light harvesting complexes; plant mitochondrial electron transport and ATP synthesis; alternate oxidase; Carbon fixation by C_3, C_4 and CAM pathways; Photoprotective mechanisms; Photorespiration; chloroplast ETC proteins and light harvesting complex, mechanism of oxidative and photophosphorylation
Nitrogen metabolism: Symbiotic nitrogen fixation, Ammonia and nitrate uptake and metabolism. Nitrate assimilation in plants: Structural features of nitrate reductase and nitrite reductase, incorporation of ammonia into organic compounds, regulation of nitrate assimilation; Ammonium assimilating enzymes – glutamine synthetase, glutamate synthase and GDH.

Unit III: Signalling in plants (15 L)
Plant Hormones: Biosynthesis and mechanism of action and cross talk - auxins, cytokinins, gibberellins, Ethylene, Abscissic acid, Salicylates, Jasmonates and Brassinosteroids.
Comparison of Animal and plant signalling systems: Protein kinases, protein phosphatases, secondary messengers.
Sensory Photobiology: Cryptochromes, phototropins; photoperiodism and biological clocks Phytochromes and its role in plant development - including flowering,

Unit IV: Stress response (15 L)

Plant response to abiotic stress: Molecular response to Water - salt content, drought and flooding and temperature stresses - heat and freezing conditions.

Response and resistance to biotic stress (viral, fungal and insects): Disease establishment factors, Pre-formed defences - anatomical, secondary metabolites (Saponins, glucosinolates, benzoxazinoids, etc), Induced Defence: Plant immunity - pathogen or microbe-associated molecular patterns (PAMPs and MAMPs), PRR triggered immunity (PTI), Effector Triggered Susceptibility (ETS), R - avr system., Synthesis of ROS, Fortification of cell walls, biosynthesis of phytoalexins, Role of salicylates, jasmonates and ethylene, Local and systemic defence.

PSLSCP103: Plant Physiology - Practical

1. Proline content in normal and saline stressed plants.
2. Effect of light/ PEG on seed germination, Stress Tolerance Index,
3. Estimation of enzyme activity (Laccase/ RNS/ ROS/antioxidant enzymes) under stress conditions.
4. Effect of hormones on seed germination (IAA/ GA) and its enzyme activity.
5. Antimicrobial effect of saponins.
6. Examples of phyllotaxy: spiral, opposite decussate, whorled.
7. Flower aestivation: valvate, imbricate, twisted and papilionaceous type.
8. The regulation of nitrate assimilation in plants/ bacteria.
9. Demonstration of apoptosis in a plant system
10. Phytoalexins: induction and bioactivity using suitable plant systems.

References:

1. Bob Buchanan, Wilhelm Gruissem and Russel Jones (2015): Biochemistry and Molecular Biology of Plants. Publisher – Wiley Blackwell.
2. Taiz and Zeiger (2003): Plant Physiology 3rd Edition: Sunderland: Sinauer Associates.
3. Lincoln Taiz, Eduardo Zeiger, Ian M. Møller, and Angus Murphy (2015): Plant Physiology and Development, 6th Edition. Sinauer Associates.
4. Hans-Walter Heldt Birgit Piechulla (2021): Plant Biochemistry 5th Edition. Academic Press.

PSLSCT104: Biostatistics and Biotechniques

Course Outcomes:
The learner would be able to:

1. Study and describe the various concepts of statistics and its applications in biology.
2. Determine and validate the results of a hypothesis.
3. Explain various concepts and methods used in Gene cloning and molecular techniques.

Unit I: Biostatistics I (15 L)
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 integration 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 finding probabilities.
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 type-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 population proportions.
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: Essentials of Gene cloning (15 L)
Cloning: Importance of DNA Cloning, Principles of Cell-based DNA Cloning and cell independent DNA cloning, Primers, PCR and its types, Cutting and Joining DNA methods - nucleases, polymerases, phosphatases, kinases, terminal transferase, adaptors and linkers, homopolymer tailing. Construction of Genomic and cDNA libraries

Vectors: Essential components of vectors and their significance, Plasmid vectors - pBR322 and pUC18, Vectors based on the bacteriophage Lambda, Cosmids, M13 vectors, YACs and BACs. Expression vectors - bacterial, mammalian and plant. Use of plant viruses as episomal expression vectors. Use of *Agrobacterium tumefaciens* and *A. rhizogenes* plasmids, Direct DNA transfer to plants, Production of transgenic mice, ES cells can be used for gene targeting in mice.
Methods of DNA transfer in eukaryotic and prokaryotic cells: Transfection methods, use of liposomes, adenovirus, biolistics, microinjection, electroporation, and transformation, transduction, and protoplasts transformation, ultrasonication.

Unit IV: Cell and Molecular Techniques (15 L)
Microtomy: Principles and types, sample preparation and sectioning parameters. Histology
Microscopy: Basic principles, instrumentation, sample preparation for optical, phase- contrast, interference, polarisation, inverted, fluorescence, confocal and electron microscopes and their applications
Electrophoresis: Principles and types of electrophoresis and their applications for proteins, nucleic acids, including gradient gel and pulse-field gel electrophoresis, gel matrices- polyacrylamide, agarose etc, critical parameters for optimum separation and resolution , two dimensional electrophoresis(IEF).
Molecular Techniques: ELISA, RIA, Immunoprecipitation - single and double, RFLP, RAPD, AFLP, Blotting techniques: Southern, Western and Northern, In - situ Hybridization: FISH, GISH SKY, Chromosome Painting.
Biophysical Techniques: X-ray crystallography, Nuclear Magnetic Resonance (NMR) spectra, Magnetic Resonance Imaging (MRI – fMRI) lasers in biology and medicines.

PSLSCP104: Biostatistics and Biotechniques - Practical.

1. Biostatistics: Solving problems using Students t Test, ANOVA and Regression analysis.
2. Isolation of plasmid from *E. coli.*
3. Agarose gel electrophoresis of isolated plasmid DNA
4. Transformation of *E.* coli cells
5. Electroporation of *E coli.* (Demonstration)
6. PCR amplification of 16s rDNA from *E. coli*
7. Western Blotting (Demonstration).
8. Sandwich ELISA. (Demonstration)
9. RAPD of plants/microorganisms/animal systems
10. Cloning of GFP gene.

References:

1. Brown T. A (2016). Gene Cloning and DNA Analysis: An Introduction. 7th Edition. Wiley and Sons
2. M. Green and J. Sambrook (2012). Molecular Biology: A laboratory Manual, 4th edition. Cold Spring Harbor Laboratory Press
3. Slater, A., Scott, N. W., & Fowler, M. R. (2003). Plant Biotechnology: The Genetic Manipulation of Plants. Oxford: Oxford University Press.
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5. Gordon, I. (2005). Reproductive Techniques in Farm Animals. Oxford: CAB International.
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11. Bratati Banerjee (2018): Mahajan's Methods In Biostatistics For Medical Students And Research Workers
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SEMESTER II

PSLSCT201: Biochemistry

Course outcomes:
The learner would be able to:

1. Understand the classification, structure and biological role of various carbohydrates, vitamins and minerals.
2. Explore the structural and functional aspects of proteins and lipids
3. Explain the mechanism of action of enzymes and their regulation
4. Recognize the significance of biochemical techniques in understanding the structure-function relationship of the biomolecules

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

Carbohydrate: Classification and stereochemistry, structure, properties and biological roles of storage and structural carbohydrates such as sucrose, starch, glycogen, cellulose, pectin, hemicelluloses, chitin, mucopolysaccharides. Glycoproteins, proteoglycans, glycolipids. Applications of carbohydrates (biofuel, industrial and therapeutic).

Vitamins: Structure, sources and biological roles of water soluble and lipid soluble vitamins, Nutritional requirements of vitamins (National and international), Deficiency and excess disorders of vitamins

Minerals: Sources and biological roles of bulk and trace elements, Nutritional requirements of minerals (National and international), Deficiency and excess disorders of minerals

Unit II: Protein and Lipids (15 L)

Protein: Structure, classification and properties of Amino acids; Peptide bonds and Primary structure; Secondary structure eg. Keratin, Collagen; Ramachandran plot; Tertiary structure and the underlying interactions/ forces, quaternary structure and with references to haemoglobin; and quinary structure. Protein folding and denaturation; Domains and motifs; Cytoskeletal and extracellular proteins; Isolation, purification and characterization of proteins; Applications of proteins (industrial and therapeutic); Parameters of protein quality (Biological value, net protein utilization, protein efficiency rate, digestibility)

Lipids: Structure, classification and properties of lipids; Lipid peroxidation; Lipid analysis in Foods; Formation of liposomes and drug targeting.

Unit III: Enzymology (15 L)

Enzyme: Enzyme and enzyme substrate interactions; chemical modification and identification of active site amino acids; Enzyme kinetics (Michaelis-Menten equation and plot, Lineweaver-Burk plot, significance of Km and Vmax); Catalytic efficiency of enzymes; Mechanism of enzyme

catalysis with reference to chymotrypsin/lysozymes/metalloenzymes; Role of metals in catalysis with reference to carboxypeptidase; Therapeutic and industrial applications of enzymes.
Regulation: Regulation of enzyme action; Theory of allostery with reference to ATCase; Isozymes with reference to LDH; Coenzymes and their roles; Enzyme inhibitors, types and their kinetics; Enzyme inhibitors as drugs; Ribozymes and Abzymes.

Unit IV: Biochemical Techniques (15 L)
pH, Buffers and colorimetry: Principles and theory, pH meters.
Centrifugation: Principles and types, simple and differential, ultracentrifugation – preparative and analytical.
Chromatography: Principle, methodology and applications of chromatography using (paper, thin layer, column (gel filtration, ion exchange, affinity, gas, HPLC,FPLC etc).
Colorimetry and spectroscopy: Basic principles, nature of electromagnetic radiation, Beer-Lambert laws, colorimetric methods and instruments, principles of spectroscopy ,types of spectra- absorbance, emission, fluorescence and action spectra, single and double beam spectrophotometers, densitometers, circular dichroism and their applications.

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

PSLSCP201: Biochemistry – Practical

1. Enzyme kinetics: effects of pH, temperature, time and substrate concentration, determination of Km and Vmax using acid/alkaline phosphatase/Amylase, specific activity.
2. Isolation and purification of proteins/enzymes
   a. Extraction of proteins from plants/bacteria
   b. Partial purification using salt fractionation and dialysis
   c. Purification using chromatographic and/or electrophoretic techniques
   d. Measurement of purification fold
3. Analysis of lipids (iodine number/acid value/ saponification number/Peroxide value
5. Lipid peroxidation by Thiobarbituric acid reactive substances (TBARS) method
6. HPLC (demonstration)
7. Separation of natural products by HPTLC (demonstration).
8. Isolation of cell organelles to demonstrate Density gradient centrifugation

References:

1. L. Stryer (2002): Biochemistry, W.H. Freeman and Co. 5th Edition.
2. Voet, Donald, Voet Judith, Pratt, Charlotte W. (2006): Fundamentals of Biochemistry: Life at the molecular Level 2nd Edition. Publisher: Asia, John Wiley & Sons.
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4. Text Book of Biochemistry with clinical correlation by Thomas M. Devlin, John Wiley - Liss, Hobokhen NJ publishers
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11. Lesk, A. M. (2004) Introduction to Protein Science: Architecture, Function and Genomics. Oxford University Press, UK.
12. Creighton, T.E. (1983) Proteins: Structures and Molecular Properties. W.H. Freeman and Co., USA.
13. Arai, M. and Kuwajima, K. (2000) Advances in Protein Chemistry. Academic Press, USA
14. David E Metzler (2001. 2002): The Chemical Reactions of Living Cells – Vol1 and 2.
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PSLSCT202: Molecular Biology

Course Outcome:
The learner will:

1. Obtain an in depth understanding of the basic processes of life
2. Get an insight into the molecular mechanisms that govern the various life processes
3. Gain extensive knowledge of the synthesis and processing of both RNA and proteins and their interactions with other macromolecules
4. Get an understanding of the regulatory mechanisms that operate within prokaryotes and eukaryotes to control gene expression
5. Be able to apply the knowledge gained in research and industry environments.

Unit I: Basics of Life Processes I (15 l)

Genome: Satellite DNA, Tandem repeat array, Transposons: LINE and SINE, Tn and IS elements.

DNA replication: Fidelity and processivity of replication, DNA Polymerases - subunits and functions. The clamp and its loader- leading and lagging strand. Primer removal- leading and lagging strand.

Extrachromosomal replication: Mitochondria, Chloroplast and Plasmid

DNA repair: Direct repair, Excision of base pair, Post replicative, SOS.

Recombination: Homologous and Non Homologous.

Epigenetics: History and Hypothesis, Effect on chromatin structure- Nucleosome, Imprinting- DNA Methylation, its mechanism and inheritance, Gene Expression- Histone Modification Mechanism (Methylation, Acetylation, Phosphorylation, Ubiquitination), Effects of Environmental factors, Disorders- Imprinting and Cancer (Oncogene and Tumour Suppressor gene).

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

Transcription: Classes of RNA molecules - structure and function. Transcription unit.

Transcription in prokaryotes: *E.* coli RNA polymerase, transcription activators and repressors, Mechanism - initiation, elongation and termination, processing of tRNA and rRNA in *E. coli*.

Transcription in Eukaryotes - RNA Polymerases of eukaryotes, RNA polymerase II Promoters, Hypersensitive sites, long distance regulatory elements - enhancers, silencers and insulators, Mechanism of transcription - formation of initiation complex, elongation & termination, Eukaryotic Promoters for RNA polymerase III and transcription of rRNA and tRNA.

RNA processing - Capping and polyadenylation, major and minor splicing systems, RNA editing, Processing of eukaryotic rRNA genes, formation of eukaryotic tRNA molecules, Processing of small RNA molecules and RNA interference

Translation:

Ribosomes: Properties of the prokaryotic and eukaryotic ribosomes, ribosome biogenesis.

Translation process: Mechanism - Initiation, elongation and termination in 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.

Unit III: Protein Processing and its interaction (15 L)

Protein processing and folding: Polypeptide processing – cleavage of signal peptide, propeptide, protein splicing, protein folding pathways - role of chaperones, chaperonins, heat shock proteins, enzymes and other factors, Folding intermediates - molten globule and foldon, methods to study protein folding - x-ray crystallography, fluorescent spectroscopy, circular dichroism.

Post-translational modification of proteins – Types of post translational modifications - glycosylation, phosphorylation, acetylation, methylation, ribosylation, prenylation, palmitoylation, myristoylation, give examples and explain its role in regulation of gene expression and enzyme activity, protein targeting, mutational effects.

Protein-protein interactions: Types of interactions, interacting protein domains - SH2, SH3, LIM, SAM, PDZ, protein networks and complexes, structural properties of interacting proteins, forces of interaction, thermodynamics and energetics, regulation, Methods of studying protein protein interactions - Pull-down assay, Yeast two hybrid assay, Co-immunoprecipitation assay, Fluorescence resonance energy transfer (FRET), surface plasmon resonance and theoretical prediction of protein – protein interactions, biotechnological and medical applications.

Protein - DNA interactions – Sequence specific DNA binding, DNA and RNA binding domains, thermodynamics, methods of study - Electrophoretic mobility shift assay (EMSA), DNase I footprinting, Chromatin immuno-precipitation assay, medical and biotechnological applications

Unit IV: Regulation of Gene expression (15 L)

Regulation of Gene expression in Prokaryotes: General aspects of Regulation,
regulation - inducible and repressible systems, positive and negative regulation; Regulation of lactose, tryptophan, arabinose and galactose operons, Regulons, Master switches, Regulation of Translation - Regulation of the synthesis of Ribosomes, mRNA structure, mRNA half-life, unregulated changes in gene expression. Feedback Inhibition, Role of riboswitches, ribozymes and small RNA molecules, Two component regulatory systems - Phosphate regulon.

Gene expression in Eukaryotes: Regulatory strategies in Eukaryotes, Regulation of transcription - Role of transcription factors, mediators, regulatory sequence elements, nucleosome remodelling factors and histone modification, posttranslational modifications of transcription initiation factors, methylation and epigenetics, Regulation through RNA processing

- RNA splicing and RNA degradation, role of RNA interference. Translational control - Role of translation repressors, polyadenylation and translation factors. Regulation in response to environmental stimuli, hormones and signaling factors. Regulation of gene expression in plant cells by light. Diseases associated with defects in regulation

PSLSCP202: Molecular Biology – Practical.

1. Regulation of the lactose operon and estimation of beta galactosidase enzyme activity in *E. coli*.
2. Isolation of histones from a suitable system.
3. Methylation specific PCR
4. Isolation of phosphoproteins from cell extracts (demonstration)
5. Sucrose gradient gel electrophoresis.
6. Genomic DNA isolation and confirmation
7. Comparative study of Light and Dark Repair Mechanism in *E. coli* by UV radiation
8. UV sensitivity of *recA* mutants
9. Study of protein denaturation and renaturation using fluorescent spectroscopy

References:

1. Benjamin Pierce (2013). Genetics: A conceptual Approach 5th Edition. W. H. Freeman And Company
2. Harvey Lodish, Arnold Berk, S Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James Darnell Molecular Cell biology: 5th Edition and above.
3. Geoffrey Cooper (2018). The Cell: A Molecular Approach 8th Edition. Oxford University Press
4. An introduction to Molecular Biotechnology–Molecular fundamentals, methods and applications in Modern Biotechnology (2006): ed. Micheal Wink
5. Walker John M. and Ralph Rapley (2015). Molecular Biology and Biotechnology 6th Edition. RSC Publishing
6. Lehninger, Nelson and Micheal Cox (2017). Principles of Biochemistry 7th Edition. W. H. Freeman and Macmillan Learning, New York
7. Lewin B. Micheal Stone (2008). Genes IX. Jones and Barlett Publishers Ltd.
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10. James D. Watson, A. Baker Tania, P. Bell Stephen, Gann Alexander, Levine Michael, Losick Richard (2016). Molecular Biology of the gene 7th edition Pearson Publishers
11. M. Green and J. Sambrook (2012). Molecular Biology: A laboratory Manual, 4th edition. Cold Spring Harbor Laboratory Press

PSLSCT203: Animal Science

Course outcome:
The learner would be able to:

1. Explain the anatomy and physiology of cardiovascular, digestive and excretory systems.
2. Describe the general physiology of finfish/shellfish.
3. Understand the concepts of development, mechanism of gamete production and fertilization in animals.
4. Explain the anatomy and physiology of central nervous system and the peripheral nervous system including the structure and function of the sensory and motor systems.
5. Describe the structure, functions and disorders of different endocrine glands.

Unit I: Animal Physiology (15 L)
Blood: Blood corpuscles, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin, haemostasis.
Cardiovascular System: structure of heart, cardiac cycle, blood pressure, control of blood pressure, neural and chemical regulation.
Physiological Systems: Digestive system, Excretory system.
General physiology of aquatic life: with example of Finfish/Shellfish.

Unit II: Developmental biology (15 L)
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 (15 L)
Overview: Central Nervous System (CNS), peripheral nervous system (PNS) and autonomic nervous system (ANS) - 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.

Unit IV: Endocrinology (15 L)
Endocrine system: Structure and functions of Endocrine glands- 1. Pituitary gland 2. Thyroid gland, 3. Pancreas gland 4. Adrenal gland.

PSLSCP203: Animal Science – Practical

1. Chick embryology- Fresh Mounting.
2. Permanent slides of different stages of chick embryo.
3. Neutral red staining for apoptosis in developing chick embryo.
4. Animal physiology dissection of (Finfish/Shellfish) to study internal organs.
5. Study of ECG in humans.
6. Study of EEG in humans.

References:

1. L. Wolpert, R. Beddington, J. Brockes, T. Jesell and P. Lawrence. (2002): Principles of Development, Oxford University Press.
2. W.A. Miller (1997): Developmental Biology. Springer – Verlag.
3. S.F. Gilbert.(1994): Developmental Biology, Sinauer Associates Inc. Publishers (4th edition).
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8. E. R. Kandel, J.H.Schwartz and T.M. Jessel (2012): Principles of Neural Science, Hall International.
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10. C. Guyton and J.E.Hall (2006): Text Book of Medical Physiology 11th Edition. College Publishers.
11. G. Tortora and S. Grabowski John. (2003): Principles of Anatomy and Physiology, 10th edition. Wiley & Sons, Inc. G. M. Shepherd (): Fundamentals of Neurobiology, University Press, 3rd Edition.
12. C.U.M. Smith (): Elements of Molecular Neurobiology, Wiley and sons Publication.

13. Talwar and Srivastava (2002): Text Book of Biochemistry and Human Biology: (3rd Edition). PHI learning
14. Dr. Himanshu Arora Dr. Mohan P. Arora (2016): Developmental Biology. Himalaya Publishing House.
15. TVR & Kutty M.N (2005): Aquaculture: Principles and Practices, Blackwell, 2ndEd.
16. Ujwala Jadhav (2010): Aquaculture Technology and Environment. Publ. PHI Publication.

PSLSCT204: Bioinformatics, IPR and Bioethics

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 (15 L)
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 in databases
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 (15 L)
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 E value.
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 (15 L)
Genomics: Basic concepts on identification of disease genes, role of bioinformatics-OMIM database, reference genome sequence, integrated genomic maps, gene expression profiling (SAGE, qPCR); identification of SNPs, SNP database (DbSNP). Role of SNP in Pharmacogenomics, SNP arrays (microarrays).
Proteomics: Introduction and current status, *in vitro* techniques- 2D gel electrophoresis, X-ray crystallography, NMR, LC-MS, GC-MS, sequencing. 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 Modelling, fold recognition, threading

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

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 and IPR provisions under TRIPS; 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, case studies.

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.

PSLSCP204: Bioinformatics, IPR and Bioethics – Practical.

1. Multiple sequence alignment and Phylogenetic tree analysis
2. BLAST- BLASTn, BLASTp, primer BLAST.
3. Motif Finding- MEME and myhits
4. Secondary Structure Prediction: Interproscan
5. CATH and SCOP
6. KEGG
7. Tertiary Structure: PDB, Rasmol
8. Homology Modelling – SWISS-MODEL
9. Case study : *Enola Beans* case, Turmeric case, Neem case, Basmati case

References:

1. Attwood T. K., Parry-Smith D. J and Phukan S. (2009). Introduction to Bioinformatics. Pearson Education
2. Mount D. W. (2004). Bioinformatics: Sequence and Genome Analysis. Cold Spring Habour Laboratory
3. Pevsner J. (2015). Bioinformatics and Functional Genomics. Wiley-Blackwell
4. Harisha S. (2019). Fundamentals of Bioinformatics. Dreamtech Press
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8. Talwar S. (2008). WTO And Intellectual Property Rights. Serials Publication
9. Ganguli P. (2017). Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets. McGraw Hill Education

Notes:

The course is designed considering that the learner is familiar with the basics of the following. The learner is advised to revise the following topics for better understanding of the syllabus.

Mendelian Genetics: Dominance, Segregation, Independent Assortment

Basics of Immunology: Concepts of Antigen, Antibody and their reactions. Innate immunology. Cells of the Immune system.

Structure of Gene: Monocistronic and Polycistronic, Promoter, Operator, ORF, Terminator, Gene families, Pseudogenes, Split Gene, Genomic Mutations**:** Introduction, Deletions, Addition, Insertion, Inversions and Translocations. Chromatin Structure: Histones, Non-Histones, Scaffolding proteins.

8. OVERALL EXAMINATION AND MARKS DISTRIBUTION PATTERN

SEMESTER I

	COURSE CODE												
THEORY	PSLSCT101			PSLSCT102			PSLSCT103			PSLSCT104			GRAND TOTAL
Theory	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
Practical	PSLSCP101			PSLSCP102			PSLSCP103			PSLSCP104			GRAND TOTAL
	-	50	50	-	50	50	-	50	50	-	50	50	200

SEMESTER II

	COURSE CODE												
THEORY	PSLSCT201			PSLSCT202			PSLSCT203			PSLSCT204			GRAND TOTAL
Theory	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
Practical	PSLSCP201			PSLSCP202			PSLSCP203			PSLSCP204			GRAND TOTAL
	-	50	50	-	50	50	-	50	50	-	50	50	200