Resolution number: AC/II(23-24).2.RPS8

S. P. Mandali's

Ramnarain Ruia Autonomous College

RUIA COLLEGE
Explore ● Experience ● Excel

Syllabus for Masters of Science

Program: M.Sc. Life Science

Program Code: RPSLSc

(NEP2020 - Choice Based Credit System for the
Academic year 2024–2025)

Graduate Attributes for Masters in Science (M.Sc.)

In the post graduate courses, S.P. Mandali's Ramnarain Ruia Autonomous College is committed to impart conceptual and procedural knowledge in specific subject areas that would build diverse creative abilities in the learner. The College also thrives to make its science post graduates research/ job ready as well as adaptable to revolutionary changes happening in this era of Industry 4.0.

GA	GA Description **A student completing Master's Degree in Science program will be able to:**
GA 1	Demonstrate in depth understanding in the relevant science discipline. Recall, explain, extrapolate, and organize conceptual scientific knowledge for execution and application and to evaluate its relevance.
GA 2	Critically evaluate, analyse, and comprehend a scientific problem. Think creatively, experiment and generate a solution independently, check and validate it and modify if necessary.
GA 3	Access, evaluate, understand, and compare digital information from various sources and apply it for scientific knowledge acquisition as well as scientific data analysis and presentation.
GA 4	Articulate scientific ideas, put forth a hypothesis, design and execute testing tools and draw relevant inferences. Communicate the research work in appropriate scientific language.
GA 5	Demonstrate initiative, competence, and tenacity at the workplace. Successfully plan and execute tasks independently as well as with team members. Effectively communicate and present complex information accurately and appropriately to diverse groups.
GA 6	Use an objective, unbiased and non-manipulative approach in collection and interpretation of scientific data and avoid plagiarism and violation of Intellectual Property Rights. Appreciate and be sensitive to environmental and sustainability issues and understand its scientific significance and global relevance.
GA 7	Translate academic research into innovation and creatively design scientific solutions to problems. Exemplify project plans, use management skills, and lead a team for planning and execution of a task.
GA 8	Understand cross disciplinary relevance of scientific developments and relearn and reskill to adapt to technological advancements.

PROGRAM OUTCOMES

Program: M.Sc. Life Science

PO	Description **A student completing Master's Degree in Science program in the subject of Life Science will be able to:**
PO 1	Gain a multidisciplinary understanding of science and its related fields.
PO 2	Improve their overall personality with skills like independent thinking and innovation as well as soft skills.
PO 3	Follow good laboratory etiquettes and research ethics.
PO 4	Present themselves and their research work with confidence.
PO 5	Develop problem solving and troubleshooting abilities as well as the ability to work as a team when performing laboratory experiments.
PO 6	Appear for various competitive exams like CSIR-NET, UGC-NET, SET, GATE, ICMR, etc in the subject of Life Sciences as well as Biotechnology.
PO 7	Find employment in a variety of fields or become self-sustaining bio-entrepreneur.
PO 8	Display their creativity and express their ideas in a nurturing environment.

MSc Life Science Program Outline

The main objectives of the MSc Life Sciences Program curriculum involve:

- The application, attainment, and synthesis of knowledge.
- Improving written as well as spoken communication skills.
- Developing research skills, ethics, and etiquettes.
- Encouraging critical thinking and problem solving.

The MSc syllabus is also designed keeping in mind the highly competitive exams like the CSIR NET (Council of Scientific & Industrial Research – National Eligibility Test) which only has Life Sciences as the subject of choice for biological sciences. Qualifying this exam enables the students to receive a Junior Research Fellowship as well as eligible to apply for teaching positions at various colleges, institutes, and universities.

The Life Science program also gives students the freedom of choice to branch out and pursue whatever occupation they wish in any field of biological sciences because of the diversity of the core and elective topics. One significant advantage of being generalists in the biological sciences is the flexibility it provides in terms of job prospects. Employers often seek individuals with a broad understanding of biological sciences who can approach complex problems from multiple perspectives and collaborate with professionals from diverse backgrounds.

The program of the first two semesters allows BSc students of all biological science streams to have a common foundation in the basics of Life Sciences. The course of the first semester is designed so that every student begins on the same level before advancing to more specialised topics. It includes the basic and advanced concepts in Ecology, Cell biology, Biochemistry, Molecular Biology, etc. Topics that help to inculcate a scientific temperament and research acumen are also taught before the students begin their internship or dissertation projects. The second semester is a mix of basic as well as advanced subjects like Cellular signalling, Cancer biology, Epigenetics, Genetic manipulation, and Genetic engineering. Students also must complete a field project which tests their research aptitude.

The third semester is designed to further the knowledge of the students in the specialization of Biotechnology. Diverse topics like Tissue Culture, Advanced protein studies as well as Biomathematics are focused on. Students will also get a chance to work on an individual research project in the college itself which may lead to research publications or presentations in conferences. The final semester rounds off the program by the introduction of topics like medical biotechnology and Bioinformatics. The elective involves promising areas of Applied Biotechnology like Assisted Reproductive Technologies, Diagnostics, Forensics and Nanotechnology. Students will also get a chance to work as an intern in research institutes or in an industry and present their work at the end of the semester or continue with their Semester 3 projects which will culminate in a final presentation and thesis at the end of the fourth semester.

The teaching style encourages students to use logic and reasoning instead of rote learning. Concepts are explained through discussions, debates, presentations, and even innovative games. By the end of the program the intellectual arsenal of the students is well equipped and fortified along with the sense of responsibility and scientific temperament that will assist them in their future endeavours.

PROGRAM OUTLINE

YEAR	SEM	COURSE CODE	COURSE TITLE	CREDITS
2024-25	I	RPSLScO501 (Core Course)	Molecular Biology	4
	I	RPSLScO502 (Core Course)	Biochemical Studies	4
	I	RPSLScO503 (Core Course)	Bioanalytical Techniques and IPR	4
	I	RPSLScO504 (Core Course)	Cellular processes	2
	I	RPSRMLScO505 (RM)	Research Methodology and Scientific writing	4
	I	RPSELScO506 (DSE)	Environmental Biology, Biodiversity and Evolution	4
	II	RPSLScE511 (Core Course)	Plant Physiology and Model Organisms	4
	II	RPSLScE512 (Core Course)	Life Processes	4
	II	RPSLScE513 (Core Course)	Genetic Manipulation and Cell Signalling	4
	II	RPSLScE514 (Core Course)	Microbiology and Immunology	2
	II	RPSLScE515 (FP)	Field Project	4
	II	RPSELScE516 (DSE)	Genetic Engineering	4
Total Credits				**44**

- Discipline Specific Elective (DSE) - For biology cluster students (Botany, Life Science and Zoology)

YEAR	SEM	COURSE CODE	TYPE OF COURSE	COURSE TITLE	CREDITS
2024-25	III	RPSLScO601 (Core Course)	Discipline Specific Core I	Tissue Culture and New Emergent Technology	4
	III	RPSLScO602 (Core Course)	Discipline Specific Core II	Fermentation Technology, International Standards & Bio entrepreneurship	4
	III	RPSLScO603 (Core Course)	Discipline Specific Core III	Protein studies and Biomathematics	4
	III	RPSRPLScO605	Discipline Specific Core IV	Research Project	6
	Note: **Students should select ANY ONE (T+P) of the following Discipline Specific Electives (DSE)**				
	III	RPSELScO604	Discipline Specific Elective	Environmental Biology, Evolution and Astrobiology	4
	III	RPSEBOTO604	Discipline Specific Elective	Bioprospecting of industrial molecules	4
	III	RPSEZOOO604	Discipline Specific Elective	Introduction to model organisms	4
	IV	RPSLScE611 (Core Course)	Discipline Specific Core I	Medical Biotechnology	4
	IV	RPSLScE612 (Core Course)	Discipline Specific Core II	Bioinformatics	4
	IV	RPSINTLScE614 (Core Course)	Discipline Specific Core III	Internship	10
	Note: **Students should select ANY ONE (T+P) of the following Discipline Specific Electives (DSE)**				
	IV	RPSELScE613	Discipline Specific Elective	Applied Biotechnology	4
	IV	RPSEBOTE613	Discipline Specific Elective	Soilless Cultivation	4
	IV	RPSEZOOE613	Discipline Specific Elective	Marine Bioprospecting	4
				Total Credits	**44**

*Discipline Specific Elective (DSE) - For biology cluster students (Botany, Life Science and Zoology)

M.Sc. Part - I Life Sciences Syllabus

SEMESTER I

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	L / WEEK
Paper I	**Molecular Biology**			
RPSLScO501 (Core Course)	I	Genetics	4	4
	II	DNA Replication, Repair & Recombination		4
	III	Transcription and Translation		4
Paper II	**Biochemical studies**			
RPSLScO502 (Core Course)	I	Proteins and Lipids	4	4
	II	Carbohydrates, vitamins, and minerals		4
	III	Enzymology and Enzymes in Industry		4
Paper III	**Bioanalytical Techniques and IPR**			
RPSLScO503 (Core Course)	I	Instrumentation I	4	4
	II	Instrumentation II		4
	III	IKS and IPR		4
Paper IV	**Cellular processes**			
RPSLScO504 (Core Course)	I	Cell biology	2	4
	II	Photosynthesis, Mitochondrial and Chloroplast Electron Transport Chain		4
Paper V	**Research Methodology and Scientific Writing**			
RPSRMLScO505 (RM)	I	Research Methodology	4	4
	II	Scientific Writing		4
	III	Use of Software in Research		4
	IV	Biostatistics		4
Paper VI	**Environmental Biology, Biodiversity and Evolution**			
RPSELScO506 (DSE)	I	Environmental biology	4	4

	II	Current Environmental Issues in India and Biodiversity Management		4
	III	Evolution and Astrobiology		4

SEMESTER I

PAPER I – Discipline Specific Core (DSC)
Course Code: RPSLScO501
Course Title: Molecular Biology

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION **At the end of the course students will be able to:**
CO 1	Explain concepts related to Mendelian genetics, non-mendelian inheritance and quantitative genetics.
CO 2	Describe the concept of conjugation, transformation and transduction involved in microbial genetics.
CO 3	Compare the mechanisms involved in DNA replication, recombination and repair in prokaryotes and eukaryotes.
CO 4	Employ creative media in assignments to express the concepts learnt.
CO 5	Describe the concepts of the central dogma of life from DNA to RNA to proteins which serve the whole purpose of molecular biology.
CO 6	Compare and state differences between the transcriptional and translational process among Prokaryotes and Eukaryotes.
CO 7	Use gene mapping methods to find the distance between genes and solve population genetics related problems.
CO 8	Apply isolation methods to analyse and quantify DNA and RNA. Amplify DNA using PCR machine and perform RAPD analysis.

DETAILED SYLLABUS - Paper I

Course Code: RPSLScO501

Unit	Course/ Unit Title	Credits/ Hours
I	**Unit I: Genetics:** **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 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.**	1/ 15hrs
II	**Unit II: DNA Replication, Repair and Recombination** **DNA replication:** DNA structure, forms of DNA, Unit of replication and enzymes, replication origin and replication fork, fidelity and processivity of replication, extrachromosomal replicons (plasmid). Replication process in prokaryotes and eukaryotes. **DNA repair mechanisms:** SS damage reversal repair, SS damage excision repair (BER, NER, MMR), DS damage repair (HR, NHEJ, NMEJ), Defects in DNA repair.	1/ 15hrs
III	**Unit III: Transcription and Translation** **Transcription:** Classes of RNA molecules - structure and function. **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** - Types of eukaryotic RNA Polymerases, mRNA transcription - formation of initiation complex, elongation & termination, Upstream activation sites and enhancers, mRNA processing and modifications - capping & polyadenylation, mRNA Splicing, RNA editing, RNA Pol II & Pol III promoters, Eukaryotic rRNA genes, rRNA synthesis & processing, formation of eukaryotic tRNA molecules. **Translation:** Outline of Translation. **The Genetic Code:** The Decoding System, Codon -Anticodon interaction.	1/ 15hrs

	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: RPSLScPO501 (1 credit)

1. Study the effect of colchicine on cell stages of mitosis / meiosis using Onion root tip / *Tradescantia*.
2. Isolation of plant DNA by the CTAB protocol and RAPD analysis.
3. DNA amplification using PCR
4. Isolation and estimation of RNA from Yeast or a suitable system.
5. *In-Vitro* Transcription
6. Problems in Genetics:
    a. Problem solving: Multiple alleles, Lethal genes
    b. Problem solving: Hardy Weinberg equation, Pedigree analysis.

References:

- 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 II - Discipline Specific Core (DSC)
Course Code: RPSLScO502
Course Title: Biochemical Studies

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION At the end of the course students will be able to:
CO 1	Explain the unique properties of amino acids which influences the amazing diversity of proteins and describe the structure and properties of lipids and their role in our diet.
CO 2	Apply the basic concepts of protein biochemistry to advanced subjects like protein engineering, vaccine formulation and drug designing.
CO 3	Describe the classification, structural properties of carbohydrates along with the concept of stereochemistry and biological roles.
CO 4	Explain the structure, and role of vitamins and minerals and their importance with respect to nutritional deficiencies.
CO 5	Explain the concept of Enzyme-substrate interactions, kinetics, mechanism of catalysis and regulation of enzyme activity using appropriate examples.
CO 6	Describe various industrial applications of enzymes.
CO 7	Optimize various parameters of the enzyme assays and construct the graphs depicting enzyme kinetics.
CO 8	Extract, Estimate, Quantify and Analyse amount of Sugars, Lipids and Proteins using respective methods and compare the sensitivity of the methods used for proteins.

DETAILED SYLLABUS - Paper II

Course Code: RPSLScO502

Unit	Course/ Unit Title	Credits/ Hours
I	**Unit I: Protein and Lipids** **Protein:** Amino acid single letter codes, isoelectric point, primary structure elucidation, Ramachandran plot, secondary (alpha helix, helical wheel, beta sheets, beta turns) and super secondary structures. Tertiary structure and the underlying interactions/ forces, quaternary structure, domains and motifs. Examples of proteins - Keratin, Collagen, Haemoglobin. **Lipids:** structure, nomenclature, classification and properties of lipids, lipid assembly, model membranes, formation of liposomes and drug targeting.	1/ 15hrs
II	**Unit II: Carbohydrates, Vitamins, and Minerals** **Carbohydrate:** Classification and stereochemistry, structure, properties and biological roles of storage and structural polysaccharides such as, starch, glycogen cellulose, pectin, hemicelluloses, chitin, mucopolysaccharides. Structure and role of N and O- linked glycoproteins and proteoglycans. **Vitamins:** Structure and biological roles of water soluble and lipid soluble vitamins, vitaminosis and deficiency. **Minerals:** Structure and biological roles of bulk and trace elements.	1/ 15hrs
III	**Unit III: Enzymology and Enzymes in Industry** **Enzyme:** enzyme and enzyme substrate interactions, enzyme kinetics, 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 of enzyme activity:** theory of allostery with reference to AT case, Isozymes with reference to LDH: Coenzymes and their roles, types of enzyme inhibitors and activators and their kinetics, ribozymes and abzymes. **Industries**: Textile Processing, Leather Processing, Paper & Pulp Processing, Detergents, and laundry. **Food biotechnology**: Fruit and vegetable processing: juices, nectars, purees; syrup and glucose isomerases, enzymatic synthesis of aspartame. **Feed Biotechnology:** lignocelluloses into feed using cellulases, silage. **Other industrial uses:** Vinegar, Baking, Cocoa fermentation, Olive oil production, fish processing industries.	1/ 15hrs

PRACTICALS: RPSLScPO502 (1 credit)

1. Estimation of sugar by DNSA method from a biological source.
2. Enzyme kinetics, effects of pH, temperature, time and substrate concentration, determination of Km and Vmax using phosphatase/Amylase.
3. Lipid extraction and estimation by Bligh and Dyer method, separation of lipids by TLC.
4. Estimation of protein by Folin Lowry and Biuret methods. Compare sensitivity by using Folin Lowry method, Biuret method and UV absorbance at 280nm.
5. Estimation of phosphorus by Fiske-Subbarow method.

References

- Principle of Biochemistry, Lehninger, Albert L. (III Ed. 2000 worth pub), CBs publishers and distributors.
- Biochemistry, Stryer, Lubert, W. H. Freeman.
- Biochemistry and Molecular biology, Elliott, Willam H, Elliott, Daphne C, Oxford University Press.
- Oxford dictionary of biochemistry and molecular biology, Oxford University Press.
- Proteins- Structures and molecular properties, Creighton, T. E, Freeman, and Co.
- Biochemistry of cell membranes: a compendium of selected topics, Papa S., ed. Tager, J. M., ed, Birkhauser Verlag.
- Plant Biochemistry, Hans-Walter Heldt, Birgit Piechulla, Academic press.

PAPER III - Discipline Specific Core (DSC)
Course Code: RPSLScO503
Course Title: Bioanalytical Techniques and IPR

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION **Upon successful completion of this course, learners will be able to;**
CO 1	Explain the principles, instrumentation, and working of various microscopy and spectroscopy techniques and their applications in biological research.
CO 2	Explain the principle of PCR (Polymerase Chain Reaction) and its steps. Analyse the constraints and limitations of PCR and explain the modifications of PCR techniques and its wide range of applications in various fields of biological research.
CO 3	Illustrate the basic principles, working and applications of chromatography and tracer techniques in various fields of biological research.
CO 4	Describe the various blotting techniques used for biological research.
CO 5	Explain different forms of IPR's, procedures and the process of patent filing.
CO 6	Explain the protection of traditional knowledge, geographical indications, industrial designs, gene patenting, plant variety protection, and trade secrets.
CO 7	Determine pKa of buffers and lambda max for solutions using colorimeter / UV spectrophotometer to verify Beer-Lamberts law.
CO 8	Analyse amino acids and proteins using separation techniques including paper chromatography and SDS-PAGE.

DETAILED SYLLABUS - Paper III

Course Code: RPSLScO503

Unit	Course/ Unit Title	Credits/ Hours
I	**Unit I: Instrumentation I** **Microscopy**: Principles, instrumentation, working and applications of Fluorescence microscopy, Polarization microscopy, Phase contrast microscopy, TEM, SEM. Biological sample preparation for electron microscopy. **Spectroscopy**: IR, GC MS, LC MS, AAS, ICP- AES, Plasma Emission spectroscopy, NMR, 2D NMR. **PCR**: Principle, Steps in PCR, Constraints in PCR, Modifications of PCR techniques and its applications.	1/ 15hrs
II	**Unit II: Instrumentation II** **Chromatography** - General Principle of chromatography. Techniques and applications of Ion exchange, Affinity Chromatography and HPLC Application / validation of herbal drugs using HPTLC. **Radioactive isotopes and autoradiography** - Principle, instrumentation & technique: Geiger-Muller counter, Liquid scintillation counters. Applications of isotopes in biology. Radionuclide imaging, CT scan and PET scan. **Blotting techniques:** Southern, Western and Northern.	1/ 15hrs
III	**Unit III: IKS and IPR** Different property rights & IPR in India **IPR**: Objectives, process & scope **TRIPS & Patent laws**: Introduction & standards for patent protection WTO, WIPO, GATT & Indian Patent Laws **Protection of traditional knowledge**– objective, concept of traditional knowledge, holders, issue concerning, bio-prospecting and biopiracy; geographical indications, industrial designs, advantages of IPR, some case studies **International Depositary authority**, Gene patenting, plant variety protection, trade secrets & plant breeders right.	1/ 15hrs

PRACTICALS: RPSLScPO503 (1 credit)

1. Preparation of buffers (phosphate and acetate) and Determination of pKa
2. Determination of effect of acrylamide concentration on the mobility of proteins by Polyacrylamide Gel Electrophoresis (PAGE)
3. Determination of lambda max of KMnO4, CoCl2, methylene blue and Verification of Beer-lamberts law by colorimeter / UV Visible spectrophotometer.
4. Separation of amino acids by one/two-dimensional paper chromatography
5. Patent search and patent filing in scientific research

References:

- Berlyn GP and Miksche JP. 1976. Botanical micro-techniques and cytochemisty
- Chang R (1971). Basic principles of spectroscopy. McGraw Hill.
- Garry D Christian, James E O'reilvy 1986. Instrumentation analysis. Alien and Bacon, Inc.
- Gordon MH and Macrae M. 1987. Instrumental analysis in the biological sciences.
- Henry B Bull (1971). An Introduction to physical biochemistry. F A Devis Co.
- Wilson K and Walker JM.1994. Principles and techniques of practical biochemistry.
- Allan Peacock, H. 1966. Elementary Microtechnique. Edward Arnold Publ.
- Duddington, C.L, 1960. Practical microscopy. Pitman publ.
- Perkampus H (1992). UV-VIS Spectroscopy and its applications. Springer-Verlag.
- Pesce A J, Rosen C G, Pasty T L. Fluorescence Spectroscopy: An introduction for Biology
- Vanholdem K.E. and W.C.Johnson, 1998. Principles of Physical Biochemistry
- Hamilton, C.(2006) Biodiversity, Biopiracy and Benefits: What allegations of Biopiracy tell us about intellectual property. Blackwell publishing Ltd., Oxford.
- Heink, U and Kowarik,I. (2010) What criteria should be used to select biodiversity indicators . Biodiversity Conservation 19:3769-3797.
- Ram Reddy,S. Surekha ,M. and Krishna Reddy,V (2016). Biodiversity Traditional Knowledge Intellectual Property Rights .Scientific Publishers.
- Unnikrishna,P and Suneetha,M. (2012). Biodiversity ,traditional knowledge and community health : strengthening linkages .Institute for Advanced Studies, United Nations University ,Tokyo.
- Wood ,A., Pamela, S.E.and Johanna, M.(2000). The root causes of biodiversity loss. United Kingdom: Early –Scan Publications.

PAPER IV – Discipline Specific Core (DSC)
Course Code: RPSLScO504
Course Title: Cellular processes

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION At the end of the course students will be able to:
CO 1	Describe the structure, composition, and functions of various cell organelles in detail.
CO 2	Explain the importance of cell cycle in growth and development of an organism as well as the principles of the inheritance pattern of genes.
CO 3	Describe the detailed events of one of the highly coordinated processes of the cell cycle, its role, regulation, and checkpoints.
CO 4	Compare the mechanisms of the light and dark phases of photosynthesis, including the processes involved in CO2 fixation by the C3, C4, and CAM pathways, and explain the significance of photorespiration.
CO 5	Analyse the organization and function of light harvesting complexes in chloroplasts and their role in capturing and transferring light energy to the photosynthetic reaction centres.
CO 6	Describe the structure and function of proteins in the mitochondrial electron transport chain (ETC) and the process of oxidative phosphorylation, including the mechanism of ATP synthesis through the F0 F1 ATPase complex. Evaluate different theories of ATP synthesis and their implications.

DETAILED SYLLABUS - Paper IV

Course Code: RPSLScO504

Unit	Course/ Unit Title	Credits/ Hours
I	**Unit I: Cell Biology** **Plasma membrane:** Structure and composition, Membrane properties, Functions and Membrane models. **Endoplasmic reticulum:** Structure and function of Rough and smooth ER. **Golgi complex:** Structure and function, Cisternal progression theories**.** **Nucleus:** Structure - Nuclear envelope, Nuclear pore complex & Nuclear lamin proteins, Functions, Chromatin - Heterochromatin, Euchromatin, Packaging and models. Nucleolus - Structure and function. **Other organelles:** Lysosomes, peroxisomes, mitochondria, chloroplasts, and vacuoles. **Cytoskeleton:** Structure, Assembly & Functions of Microtubules, Intermediate filaments (types) & Microfilaments. **Introduction to cell cycle:** Stages of the cell cycle – G0, G1, S, G2 and M. Molecular events in the various cell cycle stages (Yeast / Mammalian)**.** **Checkpoints** (unreplicated DNA, spindle attachment, segregation of chromosomes, DNA Damage) **Concept of cyclin and CDKs; activation of the cyclin-CDK complexes (Yeast / Mammalian).** **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. Meiosis checkpoints (Ime2, Rec8 and monopolin)	**1/ 15hrs**
II	**Unit II: Photosynthesis, Mitochondrial & Chloroplast Electron Transport Chain** **Photosynthesis & Chloroplast ETC:** Significance of photosynthesis. The structure, chemical composition, function, and origin of Chloroplasts. Absorption of light, Photosynthesis pigments, Light energetics, Light harvesting complexes, Light and dark phase reaction mechanisms, Photorespiration. CO2 fixation by C3, C4 and CAM pathways. **Mitochondrial ETC:** structure and function of mitochondrial ETC proteins and mechanism of oxidative phosphorylation, F0 F1 ATPase, theories of ATP synthesis.	**1/ 15hrs**

References

- Principle of Biochemistry, Lehninger, Albert L. (III Ed. 2000 worth pub), CBs publishers and distributors.
- Biochemistry, Stryer, Lubert, W. H. Freeman.
- Biochemistry of cell membranes: a compendium of selected topics, Papa S., ed. Tager, J. M., ed, Birkhauser Verlag.
- Plant Biochemistry, Hans-Walter Heldt, Birgit Piechulla, Academic press.

PAPER V
Course Code: RPSRMLScO505
Course Title: Research Methodology and Scientific Writing

Course Outcomes:

COURSE OUTCOME	DESCRIPTION **Upon successful completion of this course, learners will be able to;**
CO 1	Enlist the resources for accessing scholarly articles, published papers, abstract writing and bibliographic management.
CO 2	Illustrate the skills to design good research hypotheses and select an appropriate data analysis method. Write Research and Grant proposals.
CO 3	Make use of methods of data collection, various AI tools for data analysis and ethical issues in educational research.
CO 4	Apply basic computer skills and required numerical skills necessary for the conduct of research.
CO 5	Explain the planning, conduction of experiments, results analysis and document the outcomes, troubleshooting managing interpersonal relationships and following several ethical norms.

Detailed Syllabus Paper V – Research Methodology

Course code: RPSRMLScO505

Unit	Course/ Unit Title	Credits / Hours
I	**Unit I - Research Methodology-I** **Introduction**: Research design principles, execution of work, interpretation of results. **Review of literature** **Library**: Structure of a scientific library, journals, books, Digital library and E books **Catalogue**: Classification of books (Universal Decimal System). Reprints, Secondary storage devices, Internet, open access initiative for biological sciences, INFLIBNET, INSDOC, Google Scholar, Ruia Library OPAC, OATD, Shodhganga, Shodhgangotri and N-LIST. **Preparation of index cards**: Author index and subject index; Open source, bibliography management system **Journals**: Indexing journals, abstracting journals, research journals, review journals, e-journals, Impact factor of journals, H-index, Indexing databases – Web of Science, Scimago, Indian Citation Index etc. **Interpersonal abilities:** Networking, Conflict resolution.	1/ 15hrs
II	**Unit II - Scientific Writing** **Introduction to scientific writing**: Meaning of Scientific and non-scientific writing; Scientific Vocabulary and grammar. Synopsis, Dissertations, Thesis, Posters. **Correspondence**: Formal letters, cover letters, drafting emails, replying to reviewers. **Writing a Research paper**: Title, Abstract, Introduction, Review of literature, Methodology, Observations, Results, Discussions, Summary, Conclusion, and Bibliography (Referencing and citation styles). Supplementary data. **Writing a Research Grant Proposal**: Funding agencies, guidelines, structure of research proposals – Setting a budget (Manpower, Consumables, Equipment, Travel, Contingencies, Overheads) with justifications, expected outcomes, Cost benefit analysis, Work plan, and Time schedule of activities. **Bioethics:** Definition – moral, values, ethics and ethics in biology; Role and importance of ethics in biology; Legal and regulatory issues; Bioethics in	1/ 15hrs

	healthcare, agriculture, modern biology, biotechnology, animal welfare & right / animals in research, wildlife conservation and management, commercialism in scientific research. **Scientific misconduct:** Plagiarism, Fabrication, Authorship conflicts, Salami and imalas publication.	
III	**Unit III: Use of Software in Research** **Literature Search:** Search, query formulation and organization of review. **Referencing:** Using Mendeley/ EndNote/ Zotero. (Validation of methods/selecting appropriate method for analysis) **Word Processing systems:** Microsoft Word, Google Docs, LATEX. **Image Editors:** Guidelines for publishing images, Inkscape, GIMP, Image J. Creating a multi-panel vector and raster image for research paper publishing. **Graphing & Statistics:** Using Microsoft Excel, Google Sheets, GraphPad Prism, MaxStat, IBM SPSS and R. **Presentation and Design:** Microsoft PowerPoint, Google Slides, Microsoft Publisher. Presenting numerical data - Graphical, Tabular, Animations, Slides, etc. **Creating a website for scientific communication:** Google sites, Wix website design and publishing. **Miscellaneous Tools and AI**.	**1/ 15hrs**
IV	**Unit IV: Biostatistics** Hypothesis testing: Theory of errors – Type I and Type II errors Null Hypothesis & Alternate Hypothesis Z-test Test of significance Introduction to ANOVA, One-way & two-way ANOVA Dunett's test Randomized Block Design and Latin Square. (5 problems to be solved in each category).	**1/ 15hrs**

References:

- Anderson J, Durston B H, Poole 1970. Thesis and assignment writing. Wiley eastern.
- Bedekar V. H.1982. How to write assignment and research papers, dissertations and thesis. Kanak publications.
- Kothari– C.R. 2004. Research Methodology –Methods and Techniques, New Age International LTd. Publishers, New Delhi.

- Research Methodology in the Medical and Biological Sciences by Petter Laake, Haakon Breien Benestad, Bjorn Reino Olsen (2007, Elsevier_AP)
- From Research to Manuscript A Guide to Scientific Writing (Second Edition) By Katz, Michael J. (Springer Publication)
- Science Research Writing for Non-Native Speakers of English by Hilary Glasman-Deal (Author), Imperial College Press, London, UK
- Scientific Writing and Communication by Angellka Hofmann, Oxford University Press (2014)
- Methods in Biostatistics- Mahajan P.K
- Goon,A.M., Gupta,M.K. and Dasgupta,B.1986. Fundamentals of Statistics (Vol.2). The world press Private limited, Calcutta. 17. Gupta,S.C. and Kapoor,V .K.1993. Fundamentals of applied statistics. Sultan Chand and Sons, New Delhi 18.
- Gupta,S.P. 2001. Statistical methods. Sultan Chand and Sons, New Delhi.

Khan I and Khanum (2008) Fundamentals of Biostatistics, Ukaaz Publications, Hyderabad.

PAPER VI - Discipline Specific Elective (DSE)
Course Code: RPSELScO506
Course Title: Environmental Biology, Biodiversity and Evolution

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION **At the end of the course students will be able to:**
CO 1	Explain ecological concepts, national and international environmental issues and concepts in evolution which forms the basis of phenomena like antibiotic resistance as well as cancer progression.
CO 2	Apply ecological concepts to their day-to-day life to benefit the environment and use various essential software that will help them in their respective careers.
CO 3	Explain the magnitude and distribution of biodiversity and its economic value. Describe the concepts of bioprospecting, ecotourism, and biodiversity management approaches. Examine the biodiversity of India and the importance of its conservation.
CO 4	Identify the major events and dates that provide the structure for geologic time on Earth.
CO 5	Analyse the age of fossils with the help of radio dating techniques.
CO 6	Explain the concepts of astrobiology, including the planetary habitability, extremophiles, abiogenesis, research on surviving extreme habitats, evolution of advanced life, and the astrobiology of Mars.
CO 7	Arrange data and determine diversity indices for a population study and perform probit analysis for toxicological studies.
CO 8	Identify and explain features of various fossils and aquaculture specimens.

DETAILED SYLLABUS – Paper VI - DSE

Course Code/ Unit: RPSELScO506

Unit	Course/ Unit Title	Credits/ Hours
I	**Unit I: Environmental biology** **Ecosystems:** Types of ecosystems [terrestrial (Tropical evergreen forests, Tropical deciduous forests, Deserts, Chaparral, Temperate grasslands, Savannahs and thorn forests, Temperate deciduous forests, Boreal forests/ Taiga, Tundra) and aquatic (Lentic, Lotic, Oceans, Estuaries, Coral reefs)], Habitat fragmentation and niche overlap, Competitive exclusion principle, resource partitioning, character displacement and resource management and conservation. **Community ecology:** Nature of communities; fundamental properties of biological communities (Productivity, Diversity, Complexity, Resilience, Stability, Structure); levels of species diversity and its measurement (Simpson, Shannon and Sorensen indices); edges and ecotones, Succession, disturbances and invasion. Species interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis. **Population ecology:** Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation, demes and dispersal. **Toxicology:** Basic principles of toxicology including LD50 and ED50, management of acute intoxication.	1/ 15hrs
II	**Unit II: Current Environmental Issues in India and Biodiversity Management:** **Biodiversity:** Concept, characterization, generation, maintenance and loss, Magnitude and distribution of biodiversity, economic value, bioprospecting, ecotourism and biodiversity management approaches. Biodiversity of India. **Conservation biology:** Principles of conservation, major approaches to management, conservation strategies. **Forest Conservation –** Chipko movement, Appiko movement, Silent Valley movement and Gandhamardhan movement. People Biodiversity register. **Wild life conservation projects:** Project Tiger, Project Elephant, Crocodile Conservation, GOI-UNDP Sea Turtle project, Indo-Rhino vision. **Environmental issues related to water resource projects** - Narmada dam, Tehri dam, Almatti dam, Cauvery and Mahanadi, Hydro-power projects in Jammu & Kashmir, Himachal and North-Eastern States. **Water conservation**- Watersheds, Rain water harvesting and ground water recharge. **National river conservation plan** – Namami Gange and Yamuna Action Plan. Eutrophication and restoration of lakes. Conservation of wetlands, Ramsar sites in India.	1/ 15hrs

	Soil erosion, desertification and Save Soil Movement. **Climate change -** adaptability, energy security, food security and sustainability. Carbon sequestration and carbon credits. **Environmental Disasters:** Minnamata Disaster, Love Canal Disaster, Bhopal Gas Tragedy, 1984, Chernobyl Disaster, 1986, Fukusima Daiichi nuclear disaster, 2011. **Local environmental issues** – Mithi river pollution, Destruction of mangroves, Coastal aquafarming and challenges, Air quality index of Mumbai, Dumping grounds, Urban development projects at Aarey colony and Sanjay Gandhi National Park.	
III	**<u>Unit III: Evolution and Astrobiology</u>** **Emergence of evolutionary thoughts:** Lamarck; Darwin–concepts of variation, adaptation, struggle, fitness and natural selection; Types of selection; Speciation – Punctuated equilibrium and phyletic gradualism; Modern evolutionary synthesis. Origin of cells and unicellular evolution **Palaeontology and evolutionary history:** Introduction to time scales, origins of unicellular and multicellular organisms; major groups of plants and animals; Mass extinction events; Adaptive radiation, convergent evolution and coevolution; Primate evolution, Carbon dating, fossils. **Molecular Evolution:** Concepts of neutral evolution, molecular divergence and molecular clocks; origin of new genes and proteins; gene duplication and divergence, molecular taxonomy. **Astrobiology:** Concepts, planetary habitability, extremophiles, abiogenesis, research on surviving extreme habitats, evolution of advanced life, astrobiology of Mars.	**1/ 15hrs**

PRACTICALS: RPSLScPO506 (1 credit)

1. Analysing the floral origin of pollen grains in honey.
2. Determination of the Simpson's diversity index/ Shannon index of a given population.
3. Effect of toxicity on *Daphnia / C. elegans* / Yeast / Pollen grains and Probit analysis.
4. Effect of space vacuum/ cosmic radiation on bacteria.
5. Identification of fossil specimens.
6. Identification of aqua farmed fish, prawn, pearl oyster and algae.

References:

- The Cambridge Encyclopedia of Human Evolution (Cambridge Reference Book) by Steve Jones
- Evolution by Monroe W. Strickberger, CBS publishers and distributors
- Astrobiology: An Introduction by Alan Longstaff, CRC Press.
- Astrobiology: A brief introduction by Kevin W. Plaxco and Michael Gross, The Johns Hopkins University Press.
- Biodiversity, Wilson E.O. (Ed.), National Academy Press, Washington, D. C.
- Understanding Biodiversity by David Zeigler (May 30, 2007): Amazon Press
- Fundamentals of Ecology by E.P. Odum, Cengage publishers

- Ecology and environment by P.D. Sharma, Rastogi publications
- Elements of Ecology by Smith and Smith, Pearson publishers
- Environmental Biology edited by Mike Calver*et al*: Cambridge University Press
- Molecular Environmental Biology by Seymour J. Garte, Lewis Publishers (1994)
- Basic Environmental Toxicology, Lorris G. Cockerham& Barbara S. Shane, CRC Press.
- Environmental Toxicology, David Wright and Pamela Welbourn, Cambridge university press

Modality of Assessment - DSC (Paper I, II, III, IV), Paper V and DSE (Paper VI)

Theory Examination Pattern:

- Assessment of theory is divided as Internal and External where internals are given weightage of 40% and external theory written exams are given weightage of 60%.

A) Internal Assessment: 30/40 Marks

- Internals are broken up into sub-internal assignments (10 or 20 marks) and an internal class test (20 marks).
- Sub-internal assignments include presentation on any research paper / conference/ guest lecture / design of website or brochure / quizzes / subjective tests / meme making assignment / video assignment / survey / debate pertaining to syllabus topics chosen or allotted.
- Students are informed at least a month in advance about the portions for topics of the assignments or presentations via emails or on google classroom and marking scheme in the form of rubrics are known to them and hard copies depicting the names of students with topics and rubrics are maintained as proofs with their signatures with date.
- Below is an example of the rubrics.

Rubrics chart for presentations

	Total	**80-100%**	**60-80%**	**40-60%**	**20-40%**	**0-20%**
Content	05	5	4	3	2	1
Presentation skills	05	5	4	3	2	1
Questions answered	05	5	4	3	2	1
Questions asked	03	3	2.4	1.8	1.2	0.6
Time management	02	2	1.6	1.2	0.8	0.4
Total	**20**	**20**	**16**	**12**	**08**	**04**

B) External Examination- 45/50/60 Marks

Duration - The examination duration will vary depending on the total marks allotted **(i.e., 60 marks paper - 2 ½ hrs duration, 50 marks paper - 2 hrs duration, 45 marks paper – 1 ½ hr duration)**. Theory question paper pattern is with 60% choice as shown below.

Semester	Papers	Units covered	Question numbers and choice	Marks for each question	Total marks
I	1, 2, 3, 6	1	Q1 - A, B, C, D (Any three out of four)	05	15
		2	Q2 - A, B, C, D (Any three out of four)	05	15
		3	Q3 - A, B, C, D (Any three out of four)	05	15
Total marks					**45**
Semester	**Paper**	**Units covered**	**Question numbers and choice**	**Marks for each question**	**Total marks**
I	4	1	Q1 - A, B, C (Any two out of three)	10	20
		2	Q2 - A, B, C (Any two out of three)	10	20
		1,2	Q3 - Short notes – A, B, C (Any two out of three)	05	10
Total marks					**50**
Semester	**Paper**	**Units covered**	**Question numbers and choice**	**Marks for each question**	**Total marks**
I	5	1	Q1 - A, B, C, D (Any three out of four)	05	15
		2	Q2 - A, B, C, D (Any three out of four)	05	15
		3	Q3 - A, B, C, D (Any three out of four)	05	15
		4	Q4 - A, B, C, D (Any three out of four)	05	15
Total marks					**60**

Practical Examination Pattern: 25 Marks

- Assessment of practicals only consists of External evaluation with a weightage of 25 marks.
- The pattern of the practical paper is as follows:

Semester	Papers	Question	Total marks
I	1, 2, 3, 6	Q1. Major experiment	15
		Q2. Identification	8
		Q3. Journal	2
Total marks			**25**

Overall Examination & Marks Distribution Pattern

Semester I

PAPER	EXAM	MARKS	GRAND TOTAL
I (100 marks) DSC	Theory	45	**550 marks**
	Internal	30	
	Practical	25	
II (100 marks) DSC	Theory	45	
	Internal	30	
	Practical	25	
III (100 marks) DSC	Theory	45	
	Internal	30	
	Practical	25	
IV (50 marks) DSC	Theory	50	
V (100 marks) RM	Theory	60	
	Internal	40	
VI (100 marks) DSE	Theory	45	
	Internal	30	
	Practical	25	

SEMESTER II

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	L / WEEK
Paper I	**Plant Physiology and Model Organisms**			
RPSLScE511 (Core Course)	I	Plant Physiology I	4	4
	II	Plant Physiology II		4
	III	Model Organisms		4
Paper II	**Life Processes**			
RPSLScE512 (Core Course)	I	Animal Physiology	4	4
	II	Developmental Biology		4
	III	Neurobiology		4
Paper III	**Genetic Manipulation and Cell Signalling**			
RPSLScE513 (Core Course)	I	Gene and Gene Cloning	4	4
	II	Gene Expression Regulation and Epigenetics		4
	III	Cell communication and signaling in normal cells and cancer cells		4
Paper IV	**Microbiology and Immunology**			
RPSLScE514 (Core Course)	I	Microbiology	2	4
	II	Immunology		4
Paper V **RPSLScE515 (FP)**	**Field Project**		4	4
Paper VI	**Genetic Engineering**			
RPSELScE516 (DSE)	I	Recombinant Techniques	4	4
	II	Microbial Expression systems		4
	III	Engineering Lower eukaryotes		4

SEMESTER II

PAPER I – Discipline Specific Core (DSC)
Course Code: RPSLScE511
Course Title: Plant Physiology and Model Organisms

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION **At the end of the course students will be able to:**
CO 1	Explain how plants see the world through photoreceptors and their responses to abiotic and biotic stresses.
CO 2	Describe plant development and plant cell death.
CO 3	Explain the responses of plants to abiotic stress, such as water, salt, and temperature, and explore the mechanisms of plant defence against biotic stress, including viral, fungal, and insect attacks.
CO 4	Describe the different biochemical and signalling pathways for plant hormones.
CO 5	Explain the life-cycle, stages, culturing and maintenance of certain animal model organisms.
CO 6	Choose an appropriate plant model system depending on a research objective.
CO 7	Analyse the effects of hormones and salinity on plant growth.

DETAILED SYLLABUS - Paper I

Course Code: RPSLScE511

Unit	Course/ Unit Title	Credits/ Hours
I	**Unit I: Plant Physiology I** **Material transportation:** through xylem, phloem and plasmodesmata. **Nitrogen assimilation:** Symbiotic nitrogen fixation, Ammonia and nitrate uptake and metabolism, amino acid biosynthesis. **Plant Hormones:** Biosynthesis, signalling pathways and biological activity of Auxins, Cytokinins, Gibberellins, Ethylene, Abscissic acid, Salicylic acid, Jasmonates and Brassinosteroids. **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 defence methods (anatomical, secondary metabolites, hypersensitive reactions, hormonal signals, and the R - avr system).	1/ 15hrs
II	**Unit II: Plant physiology II** **Plant Development:** Gametogenesis, germination of pollen and self-incompatibility, Double fertilization, and seed formation (one typical example of each). **Seed germination:** The hormonal and nutritional aspect of seed germination. **Root and Shoot:** Development, organization of root and shoot apical meristems. **Leaf development:** Development and phyllotaxy, stomatal movement. **Flower development:** Flower induction, Floral organogenesis and the genes involved: Examples *Arabidopsis* and *Antirrhinum*. **Sensory Photobiology:** Cryptochromes, phytochromes and phototropins. Photoperiodism and biological clocks. Role of Phytochromes in plant development. **Programmed Cell Death and Senescence in plants:** Concept, effect on pigments in plants, environmental factors, and hormonal factors.	1/ 15hrs
III	**Unit III: Model Organisms** **Nematode worm (*Caenorhabditis elegans*) -** History and description of the model. Culturing and maintenance. Research tools – Wormbase, Wormatlas, Validation of target molecules in C. elegans (genome-wide RNAi, knockouts, compound libraries, HTPS and the MOA strategy) **Fruit fly (*Drosophila melanogaster*) -** History and description of the invertebrate model. Culturing and maintenance. Research tools: Flybase, Mutant collection (Gene disruption project), Genome-wide application of genetic tools. **Western clawed frog (*Xenopus tropicalis*) -** Trans-NIH Xenopus Initiative, Xenbase **Mouse (*Mus musculus*) -** Model organism for mammalian physiology, Types used for research, The Mouse Knockout & Mutation database.	1/ 15hrs

	Zebrafish (*Danio rerio*) - Model organism to study vertebrate physiology and development. Culturing and maintenance. Research tools- Genetic screens with morpholino's. Zebra fish assays. ZFIN database **Plant model systems:** *Arabidopsis thaliana, Zea mays, Physcomitrella patens, Medicago truncatula, Populus trichocarpa, Oryza sativa*	

PRACTICALS: RPSLScPE511 (1 credit)

1. Effect of salinity on seed viability and comparison of proline content in normal and salt stressed plants.
2. Differential staining of pollen grains using fluorescent dyes.
3. Estimation of Indole Acetic Acid in plants.
4. Effect of plant hormones on plant growth and development - Leaf Senescence and Abscisic Acid / Stem Elongation and Gibberellins / Fruit Ripening and Ethylene.
5. Culturing and imaging studies *C. elegans / Drosophila* sps.

References:

- Biochemistry and Molecular Biology of Plants: Bob Buchanan (Editor), Wilhelm Gruissem (Editor) and Russel Jones.
- Plant Physiology: Taiz and Zeiger.
- Maria Duca (auth.) - Plant Physiology-Springer International Publishing (2015)
- Heldt - Plant Biochemistry 3rd ed
- Pollen biology - A laboratory manual, K.R. Shivanna and N.S. Rangaswamy
- Model organisms in Drug Discovery (edited by Pamela M. Carroll and Kevin Fitzgerald). ISBN 0-470-84893-6, John Wiley & Sons Ltd
- A Guinea Pig's History of Biology, Jim Endersby, Harvard University Press.

PAPER II - Discipline Specific Core (DSC)
Course Code: RPSLScE512
Course Title: Life processes

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION At the end of the course students will be able to:
CO 1	Compare the anatomy of various life processes like digestion, respiration, circulation, and excretion across organisms.
CO 2	Enlist the disorders arising from defects in physiological processes in humans.
CO 3	Correlate various developmental processes in an organism by explaining the important fundamental concepts of development like commitment, specifications, determination, and differentiations with appropriate examples.
CO 4	Describe the concepts of gametogenesis, fertilization, and formation of germ layers during early development processes.
CO 5	Outline the basics of neuroanatomy and neuro-cellular mechanisms like electrical & chemical signalling and neurotransmission as well as the advanced functions of the nervous system.
CO 6	Compare and state the difference between neural and chemical regulation in controlling and maintaining homeostasis within animals.
CO 7	Demonstrate temporary mounting and microtomical techniques for animal tissues.

DETAILED SYLLABUS - Paper II - Core Course

Course Code: RPSLScE512

Unit	Course/ Unit Title	Credits/ Hours
I	**Unit I: Animal Physiology:** **Vascular system:** Blood corpuscles, haematopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin, immunity, haemostasis. **Cardiovascular System:** Comparative anatomy of heart structure, cardiac tissue, cardiac cycle, blood pressure, neural and chemical regulation. **Respiratory system:** Comparative anatomy, transport and exchange of gases, neural and chemical regulation. **Digestive system:** Comparative anatomy, human digestive system, Diet and BMR. **Excretory system:** Comparative physiology, human excretory system, osmoregulation. **Endocrine system:** Structure and functions of Endocrine glands (Pituitary, Thyroid, Parathyroid, Adrenal, Pancreas – islets of Langerhans, Sex glands, Pineal, Thymus), Biological roles and mechanism of actions of hormones (protein, glycoprotein, and steroid hormones), hormonal disorders. **Thermoregulation:** Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization. **Stress and adaptation**	**1/ 15hrs**
II	**Unit II: Developmental biology** **Concepts of development:** Brief history of developmental biology, Potency, commitment, specification, induction, competence, determination, and differentiation; morphogenetic gradients; cell fate and cell lineages; stem cells; genomic equivalence and the cytoplasmic determinants; imprinting; mutants and transgenics in analysis of development. **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:** Dictyostelium - Cell aggregation, differentiation and culmination, Drosophila - axes and pattern formation, Vertebrates - eye lens induction and limb development; Differentiation of neurons; metamorphosis; environmental regulation of normal development; sex determination.	**1/ 15hrs**
III	**Unit III: Neurobiology** **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**	**1/ 15hrs**

	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. **Behaviour–** Reflexive behaviour and homeostasis, Associative and non-associative memory.	

PRACTICALS: RPSLScPE512 (1 credit)

1. Mounting of cornea and statocyst of prawn.
2. Chick embryology- Fresh mounting and preparation of permanent slides of different stages.
3. Microtomy- block preparation and histopathological study.
4. Permanent slides of tissues.
5. Study of ECG in humans.
6. H&E staining
7. Study of gut physiology in *Drosophila.*

References:

- Principles of Development: L. Wolpert, R. Beddington, J. Brockes, T. Jesell and P. Lawrence. Oxford University Press
- Developmental Biology: W.A. Miller, Springer – 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. Pub: Garland Science
- 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 International. (2012)
- Neuroscience: Exploring the brain M. F. Baer, B.W.Connors & M. A. Paradiso, William & Wilkins, Baltimore
- TextBook of Medical Physiology: A. C. Guyton and J.E.Hall, Saunders College Publishers.
- Principles of Anatomy and Physiology: G. Tortora and S.Grabowski John Wiley & Sons, Inc. 10th edition.
- Fundamentals of Neurobiology: Shepherd G M 3rd Edition, Oxford University Press.
- Elements of Molecular Neurobiology: C.U.M. Smith, Wiley, and sons Publication.
- TextBook of Biochemistry and Human Biology: Talwar and Srivastava (3rd Edison)
- Developmental Biology: Mohan and Arora.

PAPER III - Discipline Specific Core (DSC)
Course Code: RPSLScE513
Course Title: Genetic Manipulation and Cell signalling

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION **At the end of the course students will be able to:**
CO 1	Explain the structure of gene and summarize various genomic mutations associated.
CO 2	Illustrate DNA cloning techniques using suitable restriction enzyme systems and vectors.
CO 3	Compare and elaborate on prokaryotic and eukaryotic regulation of gene expression.
CO 4	Summarize the concepts of Epigenetics related to gene expression and role of histone proteins.
CO 5	Classify the distinct types of cellular signalling, receptors and signalling pathways as well as apoptosis pathways.
CO 6	Explain the concept of apoptosis, all cancer related mechanisms and its diagnosis.
CO 7	Isolation and analysis of plasmid DNA, histone proteins from suitable organism.
CO 8	Demonstration of DNA ligation and Gene cloning methods.

DETAILED SYLLABUS - Paper III

Course Code: RPSLScE513

Unit	Course/ Unit Title	Credits/ Hours
I	**Unit I: Gene and Gene Cloning:** **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. **DNA Cloning:** Importance of DNA Cloning, Cloning methods - Principles of Cell-based DNA Cloning and cell independent DNA cloning, Cutting of DNA - Restriction & modification systems types and functions, Non-R-M systems, and Joining DNA methods - DNA Ligase mechanism, Linkers, Adaptors & Homopolymer tailing. **Vectors:** Essential components of vectors and their significance, Plasmid vectors, Vectors based on the lambda Bacteriophage, Cosmids, M13 vectors, expression vectors, YACs and BACs. Genomic and cDNA libraries. Embryonic Stem cells to produce genetically modified transgenic mice and knockout mice.	1/ 15hrs
II	**Unit II: Gene Expression Regulation and Epigenetics:** **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. **Regulation of 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 of transcription factors, Regulation of processing, Regulation through RNA splicing, RNA degradation and RNA interference, Translational control. Diseases associated with defects in regulation. **Epigenetics:** Histones, Non-Histones, Scaffolding proteins. Hypothesis, Imprinting, Mechanism (Methylation and Acetylation), Cancer epigenetics, Anticipation, Penetrance and Expressivity.	1/ 15hrs

III	**<u>Unit III: Cell communication and signalling in normal cells and cancer cells</u>** Receptor ligand dynamics, nuclear receptors, Cell surface receptors, second messengers and regulation of the signalling pathway. **Signalling pathways:** (a) G protein coupled receptors (cAMP-PKA pathway, iP3-DAG pathway, Rhodopsin signalling); (b). Receptor tyrosine kinases - EGFR and Insulin signalling; (c) Guanylyl cyclase receptors; (d) TGF-β serine threonine kinase receptors; (e) JAK-STAT pathway - Erythropoietin signalling; (f) Toll-like receptors; (g) Wnt, Hedgehog and Notch pathways. **Extracellular matrix:** Fibres, cell adhesion molecules and their functions, gap junctions. **Apoptosis:** Concept of programmed cell death, Comparison with necrosis, Extrinsic and intrinsic pathways of apoptosis, detection of apoptotic cells. **Cancer:** Hallmarks of cancer, Cancer progression and metastasis, oncogenes, and tumour suppressor genes; Mechanisms to activate oncogenes, Diagnosis, and treatment of cancer. Breast cancer: classification, types, and therapies.	**1/ 15hrs**

PRACTICALS: RPSLScPE513 (1 credit)

1. Isolation of plasmid from *E. coli*.
2. Isolation of histone from yeast cells.
3. Ligation of digested Lambda DNA using T4 DNA Ligase.
4. Gene Cloning using Blue-white screening method.
5. Flow cytometry / Western blotting / Real-time PCR (Demonstration). Visit NIRRCH/ ACTREC/ any other institute.

References:

- 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 IV – Discipline Specific Core (DSC)
Course Code: RPSLScE514
Course Title: Microbiology and Immunology

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION **At the end of the course students will be able to:**
CO 1	Classify and explain various characteristics of the microbes.
CO 2	Describe the unique characteristics and types of bacteria, archaea, and eukaryotic microbes, including their cell structures, motility mechanisms, growth curves, and the effects of environmental factors on microbial growth.
CO 3	Enlist antibiotics classification and elaborate on mode of action, and resistance mechanisms.
CO 4	Brief the host-parasite interaction, including the mechanisms of microbial pathogenicity and disease establishment by different pathogens in animal hosts.
CO 5	Explain the lymphatic system, spleen, and lymph node structures and functions, as well as the importance of major histocompatibility complexes (MHC I and II) in immune responses.
CO 6	Outline various immunological processes that are involved in the body's defence system and the mechanisms used by the immune system to fight against viral, bacterial, parasitic infections.

DETAILED SYLLABUS Paper IV

Course Code: RPSLScE514

Unit	Course/ Unit Title	Credits/ Hours
I	**Unit I: Microbiology** **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 **Eukarya:** Algae, Fungi, Slime molds- Typical characteristics 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. **Antibiotics:** Typical 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.	**1/ 15hrs**
II	**Unit II: Immunology:** **Lymphatic system,** structure and function of spleen and lymph node. **Major Histocompatibility 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. **Disease and application:** Monoclonal antibodies, SCFV, Chimeric antibodies, bispecific antibodies, phage display, Recombinant, and polyvalent vaccines.	**1/ 15hrs**

References:

- Text book of microbiology: Ananthanarayan and Paniker; Orient blackswan
- Microbiology: Prescott and Dunn
- Immunology 5th Edition, Janis Kuby; OR Kuby Immunology 7th Edition

PAPER V

Course Code: RPSLScE515

Course Title: Field Project (4 credits)

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION **At the end of the course students will be able to:**
CO 1	Acquire hands-on experience in field sampling techniques and data collection methods specific to model organisms. They will learn to identify and locate model organisms in their natural habitats, understand their natural history, and observe their behavior and interactions within the ecosystem.
CO 2	Learn to design and execute field experiments involving model organisms. Students will develop skills in experimental design, sample collection, data recording, and analysis. They will understand the importance of control groups, replication, and randomization to ensure robust scientific investigations.
CO 3	Analyse and interpret field data collected from model organisms, applying ecological and statistical principles. Students will learn to use appropriate software tools and statistical techniques to analyse and visualize data, identify patterns, and draw conclusions regarding ecological interactions, behavior, and population dynamics.
CO 4	Develop an understanding of ethical considerations and responsible conduct during fieldwork involving model organisms. Students will learn to minimize disturbances to natural habitats and organisms, follow appropriate ethical guidelines for animal handling and welfare, and practice responsible data collection and reporting.
CO 5	Enhance their critical thinking and problem-solving skills through field-based investigations. Students will learn to adapt to unpredictable field conditions, troubleshoot challenges encountered during data collection, and develop creative solutions to address research questions and hypotheses.
CO 6	Communicate scientific findings effectively through written reports and presentations. Students will learn to analyse and synthesize field data, organize their findings, and effectively communicate their research methodologies, results, and interpretations to scientific audiences.

Paper VI – Discipline Specific Elective (DSE)
Course Code: RPSELScE516
Course Title: Genetic Engineering

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION **At the end of the course students will be able to:**
CO 1	Explain the mechanisms of various recombinant techniques & latest gene editing tools such as CRISPR/Cas.
CO 2	Summarize the use novel reporter systems, metabolic engineering aspects, in-silico modelling, and Omics analysis.
CO 3	Evaluate the importance of cloning any desired gene using suitable host and appropriate expression system.
CO 4	Compare and analyse various gene expression systems for variety of hosts including both prokaryotes and eukaryotes.
CO 5	Optimize various components and essential parameters involved in developing a gene expression system.
CO 6	Design an expression system for a suitable host organism to obtain recombinant protein product.
CO 7	Demonstrate bacterial transformation method.
CO 8	Perform replica plating, slide culture and multiplex PCR techniques.

DETAILED SYLLABUS

Paper VI - DSE

Course Code: RPSELScE516

Unit	Course/ Unit Title	Credits/ Hours
I	**Unit I: Recombinant Techniques** **Introduction to recombinant proteins.** **Modifying genes/regulating sequences/proteins:** Site-directed Mutagenesis Methods: Error prone PCR, Cassette mutagenesis, Site Saturation mutagenesis, Overlap PCR, DNA/Domain/Exon shuffling, ICTHY, SCRATCHY, RACHITT. **Expression:** phage, cell, DNA, RNA, ribosome and IVC display, **Genome editing:** Homologus recombination, zinc finger nuclease, TALENS, CRISPR/Cas9, Modified nucleases – meganuclease. **Application of RNAi in strain improvement:** use of siRNA, shRNA, miRNA, ribozymes and riboswitches to regulate and optimize gene expression. **Metabolic Engineering:** Metabolic pathway analysis and modelling – approaches, Methods for metabolic engineering, Model organisms – *E. coli, B. subtilis, Saccharomyces*, Industrial applications.	1/ 15hrs
II	**Unit II: Microbial Expression Systems** **Prokaryotic: *E. coli*:** Expression systems – pET, pBAD, λPL, prhaBAD systems, Expression of Foreign Genes in Bacteria – Problems, optimization of expression: host, transcriptional, translational, post translational compatibility, solubility and purification, transport and localization (use of Promoters, Ribosome Binding Site, Fusion Proteins, signal sequences, Tags and cleavage sites), Modification of gene – codon optimization, host strain modification Expression of Native Proteins, Detecting Expression of Foreign Genes. **Gram Positive Bacteria:** *Bacillus subtilis, Lactobacilli, Streptomyces* – Expression systems, optimization of expression and applications.	1/ 15hrs
III	**Unit III: Engineering Lower Eukaryotes** **Algae -** Genetic modification - transformation strategies, selection markers, promoters, terminators, translational regulation of protein production, applications – increasing photosynthetic efficiency, yield of commercial and therapeutic products. **Filamentous fungi –** Host strains, transformation strategies, selection markers, promoters, terminators, translational regulation of protein production, humanization of filamentous fungi (*Aspergillus*, etc.), applications - pharmaceutically important secondary metabolites, medicinal mushrooms (*Ganoderma*, etc.), polysaccharides from basidiomycetes for immunostimulatory and anticancer activity. **Yeasts:** Yeast Selectable Markers and Vector Systems, commercially used yeast strains (*S. cerevisiae* and *Pichia*) and their expression systems.	1/ 15hrs

	Heterologous Protein Production - Design parameters: Source of DNA, Heterologous mRNA and protein levels and downstream applications, humanization of yeast for post translational compatibility. **Uses:** YAC Technology, Constructing Gene Knockouts and Novel Reporter Systems, synthesis of commercially important compounds. **Protozoa:** Advantages of protozoan expression systems, cultivation and applications of protozoan biotechnology.	

PRACTICALS: RPSELScPE516 (1 credit)

1. Transformation of *E. coli*.
2. Slide culture of filamentous fungi with nuclei staining using DAPI stain.
3. Replica Plating technique.
4. Identification and culture of algae / filamentous fungi / yeast.
5. Multiplex PCR.

References:

- Molecular Biology and Biotechnology, 5th and 4th edition by J. M. Walker and R. Rapley
- Biotechnology, Concepts and Applications by R. R. Vittal and R. Bhat
- Biotechnology, Principles and Applications by S. C. Rastogi More Gene Manipulations in Fungi by J. W. Bennette and Linda L. Lasure
- Microbial Metabolism and biotechnology, ebook by Horst Doelle
- The Metabolic Pathway Engineering Handbook- Fundamentals Christina D Somlke
- Systems Biotechnology for strain improvement. Trends in Biotechnology. Volume 3 (7), 2006.
- Molecular Biology: A laboratory Manual, 2nd edition, 1989: Maniatis, Fritsch and Sambrook
- Molecular Biology: A laboratory Manual, 4th edition, 2012: M. Green and J. Sambrook

Modality of Assessment - DSC (Paper I, II, III, IV), Paper V and DSE (Paper VI)

Theory Examination Pattern:

- Assessment of theory is divided as Internal and External where internals are given weightage of 40% and external theory written exams are given weightage of 60%.

A) Internal Assessment: 20/30 Marks

- Internals are broken up into sub-internal assignments (10 marks) or/and an internal class test (20 marks).
- Sub-internal assignments include presentation on any research paper / conference/ guest lecture / design of website or brochure / quizzes / subjective tests / meme making assignment / video assignment / survey / debate pertaining to syllabus topics chosen or allotted.
- Students are informed at least a month in advance about the portions for topics of the assignments or presentations via emails or on google classroom and marking scheme in the form of rubrics are known to them and hard copies depicting the names of students with topics and rubrics are maintained as proofs with their signatures with date.
- Below is an example of the rubrics.

Rubrics chart for presentations

	Total	**80-100%**	**60-80%**	**40-60%**	**20-40%**	**0-20%**
Content	05	5	4	3	2	1
Presentation skills	05	5	4	3	2	1
Questions answered	05	5	4	3	2	1
Questions asked	03	3	2.4	1.8	1.2	0.6
Time management	02	2	1.6	1.2	0.8	0.4
Total	**20**	**20**	**16**	**12**	**08**	**04**

B) External Examination- 50/45 Marks

Duration - The examination duration will vary depending on the total marks allotted **(ex. 50 marks paper - 2 hrs duration, 45 marks paper – 1 ½ hr duration)**. Theory question paper pattern is with 60% choice as shown below.

Semester	Papers	Units covered	Question numbers and choice	Marks for each question	Total marks
II	1, 2, 3, 6	1	Q1 - A, B, C, D (Any three out of four)	05	15
		2	Q2 - A, B, C, D (Any three out of four)	05	15
		3	Q3 - A, B, C, D (Any three out of four)	05	15
Total marks					**45**
Semester	**Paper**	**Units covered**	**Question numbers and choice**	**Marks for each question**	**Total marks**
II	4	1	Q1 - A, B, C (Any two out of three)	10	20
		2	Q1 - A, B, C (Any two out of three)	10	20
		1,2	Q3 – Short notes – A, B, C (Any two out of three)	05	10
Total marks					**50**

Practical Examination Pattern: 25 Marks

- Assessment of practicals only consists of External evaluation with a weightage of 25 marks.
- The pattern of the practical paper is as follows:

Semester	Papers	Question	Total marks
II	1, 2, 3, 6	Q1. Major experiment	15
		Q2. Identification	8
		Q3. Journal	2
Total marks			**25**

Modality of Assessment – Field Project

Semester	Paper	Question	Total marks
II	RPSLScE515	Proposal writing, presentation with review article	10
		Project table work	50
		Thesis submission	20
		Final presentation & viva	20
Total marks			**100**

Overall Examination & Marks Distribution Pattern

Semester II

PAPER	EXAM	MARKS	GRAND TOTAL
I (100 marks) DSC	Theory	45	**550 marks**
	Internal	30	
	Practical	25	
II (100 marks) DSC	Theory	45	
	Internal	30	
	Practical	25	
III (100 marks) DSC	Theory	45	
	Internal	30	
	Practical	25	
IV (50 marks) DSC	Theory	30	
V FP (100 marks)	Presentation	30	
	Report	50	
	Viva	20	
VI (100 marks) DSE	Theory	45	
	Internal	30	
	Practical	25	

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M.Sc. Part - II Life Sciences Syllabus
Specialization - Biotechnology

SEMESTER III

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	Hrs / WEEK
Paper I	**Tissue Culture and New Emergent Technology**			
RPSLScO601 (Core Course)	I	Plant Tissue Culture	4	4
	II	Animal Tissue Culture		4
	III	New Emergent Technology		4
Paper II	**Fermentation Technology, International Standards and Bioentrepreneurship**			
RPSLScO602 (Core Course)	I	Upstream and Downstream Processes	4	4
	II	Fermentation processes		4
	III	International Standards and Bioentrepreneurship		4
Paper III	**Protein Studies and Biomathematics**			
RPSLScO603 (Core Course)	I	Protein Trafficking and Targeting	4	4
	II	Protein folding and Biomolecular interactions		4
	III	Biomathematics		4
Paper IV	**Environmental Biology, Biodiversity and Evolution**			
RPSELScO604 (DSE)	I	Environmental biology	4	4
	II	Current Environmental Issues in India and Biodiversity Management		4
	III	Evolution and Astrobiology		4
Paper IV	**Bioprospecting for Industrial Molecules**			
RPSEBOTO604 (DSE)	I	Bioprospecting for crop protection and anti-microbial products	4	4
	II	Algal Biomass for high-value biomolecules		4
	III	Bioprospecting for flavours and fragrance		4

Paper IV	**Introduction to Model organisms**			
RPSEZOOO604 (DSE)	I	*Hydra & Drosophila*	4	4
	II	Zebrafish		4
	III	*Caenorhabditis elegans*		4
Paper V	**Research Project**			
RPSRPLScO605		Research Project		6

SEMESTER III

PAPER I – Discipline Specific Core (DSC)
Course Code: RPSLScO601
Course Title: Tissue Culture and New Emergent Technology

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION **At the end of the course students will be able to:**
CO 1	Classify plant secondary metabolites and explain the industrial production of some important metabolites.
CO 2	Enlist applications of transgenic plants and give importance of genetically modified organisms.
CO 3	Develop skills in identifying and controlling contamination in tissue cultures, including disinfection methods and strategies for managing microbial contaminants.
CO 4	Explain the basics of animal tissue culture, preservation, production and analysis.
CO 5	Enlist the different types of biosensors and explain its working principle and outline the fluid characteristics at the microscale applications for designing microfluidics chips.
CO 6	Summarize the basic concepts of biomimetics and explain its applications.
CO 7	Analyse effect of elicitor on production of secondary plant metabolite, perform micropropagation of ex-plant and demonstrate preparation and culturing of primary animal cell culture.
CO 8	Demonstrate the design of microfluidics system by analysing various parameters.

DETAILED SYLLABUS - Paper I

Course Code: RPSLScO601

Unit	Course/ Unit Title	Credits/ Lectures
I	**Unit I - Plant Tissue Culture** **Basics of plant tissue culture**: Laboratory set up and requirements, totipotency, macro and micro nutrients, media components and types. **Micropropagation:** Steps involved, Culturing woody plants, Advantages, Somaclonal variation **Culture:** Somatic embryogenesis and synthetic seed production. Callus culture and growth curves, Suspension cell culture. Protoplast culture, Somatic hybridization, Cybrids. **Secondary metabolites production from plants:** Secondary metabolite types (alkaloids, terpenes, tannins, lignans pigments, lipids); Examples of secondary metabolite production **(**industrial scale**)**: [shikonin, taxol (biosynthesis and bioreactor production) capsaicin/ berberine] **Contamination**: Explant source, contamination types, disinfecting agents, control of microbial contaminants. **Conservation:** Improvement, exploitation and conservation of genetic resources, Cryopreservation of genetic resources. **Plant recombinant technology:** Plant transformation by *Agrobacterium tumfaciens*, *A. rhizogenes* and its plasmid. **Applications of transgenic plants**: Overview, Recombinant proteins of pharmaceutical importance in plants including vaccine subunits, edible vaccines, from hairy root cultures. Strategies for virus resistance, Herbicide resistance, Insect resistance, nematode infections and resistance, stress resistance, Improved nutrition, improved shelf life; Novel applications: change in lipid profile for industrial purpose, novel horticultural traits. **Genetically modified organisms (GMOs):** Definition of GMOs, Release of GMO in environment – risk analysis, risk assessment and risk management, Detection and analysis of GMOs and GMO products.	**1/ 15L**
II	**Unit II: Animal Tissue culture** **Basics of animal tissue culture:** Methods of cell dissociation/separation and preparation of primary cell culture, characteristics of cells *in vitro*, cell culture growth parameters, detection, prevention, and determination of contamination in tissue culture. **Culture:** Primary cell culture, immortalized cell culture, stem cell culture and transformed cell culture. Specialized cells: bone marrow, skin cell culture, myogenesis, erythrogenesis and-chondrogenesis- *in vitro*, **Preservation:** Cryopreservation of tissues and cell lines.	**1/ 15L**

	Analysis and Production: cell synchronization, cell transformation *in vitro*, Mass cultivation- cytodex and bio fermenters. **Applications:** Stem cells & therapeutic cloning, Tissue engineering and 3D printing.	
III	**<u>Unit III: New emergent Technology</u>** **Biosensors:** Concepts. Types of biosensors: ampereometric, potentiometric, conductometric, calorimetric, peizoelectric, evanascent wave sensors, Surface Plasmon resonance, whole cell biosensors. **Biomimetics: Concept and applications:** Dry Adhesion (gecko lizard's foot), Water repulsion (lotus leaf), nanostructures in colour display (butterfly wings/ peacock feather). **Microfluidics:** Fundamental characteristics of fluidics at microscales applications of microfluidics (cell separation, dip sticks). **Biomechanics:** Introduction and Biotechnology in biomechanics.	

PRACTICALS: RPSLScPO601 (1 credit)

1. Effect of elicitor(s) on the production of a plant secondary metabolite using plant tissue culture (dye/ drug Alkaloids etc.)
2. Micropropagation of selected ex-plants.
3. Estimation of tannins using the Vanillin Hydrochloride method.
4. Establishment of a Primary Culture (ATC) using a suitable source.
5. Demonstration of Laminar Flow in Microfluidic system.
6. Construction of a lateral-flow diagnostic strip.

References:

1. Role of Biotechnology in Medicinal and Aromatics Plants by Khan and Khanum Vol.1
2. Plant Tissue Culture by M. K. Razdan.
3. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications; by Dr. R. Ian Freshney

PAPER II - Discipline Specific Core (DSC)
Course Code: RPSLScO602
Course Title: Fermentation Technology, International Standards & Bioentrepreneurship

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION **At the end of the course students will be able to:**
CO 1	Summarize the fundamental concepts of fermentation techniques, methods used for product recovery and explain the importance of effluent treatment.
CO 2	Differentiate between several types of fermenters and design the components and optimize various essential parameters required in a fermenter and derive microbial growth kinetics for fermentation processes and optimize the culture conditions to scale up the production.
CO 3	Enlist various commercial productions of important products like cell biomass, food products, chemicals and secondary metabolites on large scale basis and their applications.
CO 4	Classify & characterize various enzymes used for Biotransformation processes and their applications used commercially.
CO 5	Audit biotechnology/pharmaceutical industries as per ISO standards as well as the GMP and GLP guidelines by knowing the requirements and procedure of these certifications which may provide a basis for a future career in quality assurance or quality management.
CO 6	Write a successful business plan and investment proposal, understand how to set up their own businesses and take inspiration from successful Indian bio-entrepreneurs.
CO 7	Isolate, extract and estimate enzyme activity using suitable assay methods and demonstrate immobilisation technique.
CO 8	Isolate and Estimate alcohol content and lycopene using respective suitable methods.

DETAILED SYLLABUS - Paper II

Course Code: RPSLScO602

Unit	Course/ Unit Title	Credits/ Lectures
I	**Unit I: Upstream and Downstream Processes** **Fermenter design:** Components of the fermenter, sterilization, aeration, and agitation. **Types of Fermenters:** batch, continuous, air lift, fluidized bed, stirred tank. **Isolation and Screening of microorganisms:** Isolation of microorganisms from various sources, Preservation, Primary and Secondary Screening of microorganisms. **Fermentation Media:** Definition, Criteria, Various components, Types: crude and synthetic, sterilization, rheology of various components of media. **Microbial growth**: General parameters, growth kinetics for various fermentation and types of stock culture, scaling up of culture for fermentation. **Product recovery:** Product: internal, external, cell disruption methods: physical, chemical, and biological, precipitation, filtration, centrifugation, extraction, and purification, drying. **Product Economics:** Microbial culture, Fermentation: Upstream and Downstream processes, recovery process, product processing. **Effluent Treatment:** Need, Traditional methods disposal and disadvantage, physical, chemical, and biological methods.	1/ 15L
II	**Unit II: Fermentation processes** **Single Cell Protein, Biomass, and Immobilization:** Need of single cell production, production of bacteria, yeast, algae, fungi. Immobilization: cells and enzymes, methods of immobilization, applications. **Commercial Fermentations:** **Cheese:** Culture, Fermentation process, Applications. **Alcohol:** Wine, Commercial Ethanol (by-product fusel oils): Culture, Process and Applications. **Acids:** Lactic acid industrial production and applications. **Carbohydrate:** High fructose corn syrup. **Secondary metabolites from microbes:** Polymers, antibiotics, biosurfactants. **Biotransformations:** Classification and characteristics of enzymes – OTHLIL, applications of enzymes: (chiral synthesis of enantiomerically pure compounds, resolution of isomers). Examples of biotransformations.	1/ 15L
III	**Unit III: International Standards and Bioentrepreneurship:** **ISO:** Overview, Key principles of ISO 9000- Quality Management System	1/ 15L

	ISO 9001: Detailed study on ISO 9001:2015 standard, based on a seven principles of quality management, including a strong customer focus, the motivation and implication of top management, the process approach and continual improvement **Introduction to GMP** (Good Manufacturing Practices) and **GLP** (good Laboratory Practices) in Pharmaceutical Industries. **Biotechnology industry** - Emerging trends in biotechnology industry, organizational structure. **Setting up a Biotechnology industry** - Writing a business plan, Funding and investment sources (Government funding, angel investors, venture capitalists, strategic investors, crowdfunding, self-funding, bank loans, IPO), Government schemes for women. Exit strategy. **Licensing** - Motivations for licencing, scope, types and fees. **Technology transfer** – University technology transfer and issues involved. Government policies (National biotechnology development strategy, Maharashtra biotechnology policy, National policy on skill development and entrepreneurship). **Business ethics and CSR**. **Bioentrepreneurs** – Bio-entrepreneurship in Rural and Urban India, examples of Indian Bioentrepreneurs.	

PRACTICALS: RPSLScPO602 (1 credit)

1. Immobilization of cells.
2. Estimation of alcohol production: Sucrose/ fruit (s)/ sugarcane juice.
3. Isolation of cellulase producing microorganisms from natural source(s) and determination of cellulose activity using Filter paper assay/ carboxy-methyl cellulose assay.
4. Isolation and estimation of Nutraceuticals (lycopene/ isoflavonoids) by TLC.
5. Demonstration of a lab-scale working fermenter design.

References:

1. Principles of Fermentation Technology by Stanbury and Whitaker
2. Industrial Microbiology by Casida
3. Industrial Microbiology by Prescott and Dunn
4. Entrepreneurship and Business of Biotechnology by S. N. Jogdand
5. Economic dynamics of Modern Biotechnology by Maureen D. McKelvey, Annika Rickne, Jens Laage-Hellman
6. ISO 9000 quality systems handbook fourth edition by David Hoyle
7. International standard ISO 9001: quality management systems requirements 5th edition 2015-09-15.
8. Jürg P. Seiler - Good Laboratory Practice - the Why and the How (2005, Springer)
9. Good Manufacturing Practices and Inspection -Volume 2 (2007, World Health Organization)
10. GLP Essentials - A Concise Guide to Good Laboratory Practice by Milton A. Anderson - (2002, CRC Press).

PAPER III - Discipline Specific Core (DSC)
Course Code: RPSLScO603
Course Title: Protein Studies and Biomathematics

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION **At the end of the course students will be able to:**
CO 1	Summarize the types, mechanisms, quality control systems of protein trafficking and targeting machinery to various cellular compartments.
CO 2	Explain the concept of folding pathways involved in proteins achieving their native conformation with the associated thermodynamics aspects and the chaperon families that help in the process.
CO 3	Elaborate on the ability of all the biomolecules to interact with each other to carry out all the metabolic processes.
CO 4	Describe the concepts and list advanced tools used in the field of proteomics to give an overall perspective of complete protein studies under one roof.
CO 5	Enlist various applications of drug designing.
CO 6	Solve basic calculus problems as well as examples in biological scenarios using mathematics which is required to understand ecological modelling, growth curves, population genetics, epidemic modelling, enzyme kinetics, analysing drug efficacies as well as cancer treatment modelling to name a few.
CO 7	Isolate, perform partial purification of enzyme and determine molecular weight by SDS-PAGE separation and perform activity staining of enzyme using Native PAGE.
CO 8	Apply mathematical modelling techniques to biological problems, demonstrating proficiency in solving differential equations and analysing biological data.

DETAILED SYLLABUS - Paper III

Course Code: RPSLScO603

Unit	Course/ Unit Title	Credits/ Lectures
I	**Unit I: Protein Trafficking and Targeting** Intracellular and membrane protein trafficking and targeting; Secretory pathways in prokaryotes and eukaryotes; Co-translational transport (protease protection assay) - Endocytic pathways; Signal sequences; secretory proteins and membrane protein synthesis and docking. N-glycosylation in the ER and Golgi. Quality control - UPR, ERAD and proteosomal degradation. Post-translational transport - Targeting of mitochondrial, chloroplast, peroxisomal and nuclear proteins; Vesicle biogenesis and ER to Golgi transport; ER translocation of polypeptides (soluble and transmembrane); ER chaperons; SNAPs and SNAREs; Methods of studying Protein Transport; Disorders of protein transport.	1/ 15L
II	**Unit II: Protein folding and Biomolecular interactions** **Thermodynamics**: The laws of thermodynamics, enthalpy, entropy and free energy concepts and their relevance to biological systems. **Protein Folding:** Folding pathways; Intermediates of protein folding; Compact Intermediates; Hierarchical and non-hierarchical folding mechanisms; Molten globule structure; Role of chaperons (trigger factor, prefoldin), heat shock proteins (Hsp70, Hsp90), chaperonins (Group I & II) and enzymes in protein folding (PDI, PPI). Protein folding disorders. **Biomolecular Interactions and diseases**: Structural and functional aspects of proteins and DNA: Relationships between structure and function and their role in human diseases; Protein-DNA interactions; Protein-RNA interactions; Protein-Protein interactions; Protein aggregation; non-Enzymatic glycosylation (Protein- sugar interactions); Methods to study these interactions.	1/ 15L

III	**Unit III: Biomathematics** Introduction to mathematical modelling, Binomial Theorem (without infinite series), Determinants, Matrices, Rank of Matrices by Diagonalisation method Limit and derivatives, Differentiation (including differentiability), Successive Differentiation, Integration – Definite and Indefinite (ordinary, method of substitution, special trigonometric function, partial fraction) Differential equations --homogeneous and Linear ODE's and its simple applications to biological problems. Applications of maths in biology.	**1/ 15L**

PRACTICALS for RPSLScPO603 (1 credit)

1. Isolation and determination of the enzyme activity of Acid/ Alkaline phosphatase from potato.
2. Analysis of partial purification fold of the extracted enzyme.
3. Determination of molecular weight of enzyme by SDS-PAGE.
4. Activity staining of enzyme using Native PAGE.
5. Mathematical modelling.

References:

1. Molecular cell biology by Lodish (5^{th} Edition).
2. Biochemistry by Stryer.
3. Biochemistry by Harper.

PAPER IV - Discipline Specific Elective (DSE)
Course Code: RPSELScO604
Course Title: Environmental Biology, Evolution and Astrobiology

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION **At the end of the course students will be able to:**
CO 1	Explain ecological concepts, national and international environmental issues and concepts in evolution which forms the basis of phenomena like antibiotic resistance as well as cancer progression.
CO 2	Apply ecological concepts to their day-to-day life to benefit the environment and use various essential software that will help them in their respective careers.
CO 3	Explain the magnitude and distribution of biodiversity and its economic value. Describe the concepts of bioprospecting, ecotourism, and biodiversity management approaches. Examine the biodiversity of India and the importance of its conservation.
CO 4	Identify the major events and dates that provide the structure for geologic time on Earth.
CO 5	Analyse the age of fossils with the help of radio dating techniques.
CO 6	Explain the concepts of astrobiology, including the planetary habitability, extremophiles, abiogenesis, research on surviving extreme habitats, evolution of advanced life, and the astrobiology of Mars.
CO 7	Arrange data and determine diversity indices for a population study and perform probit analysis for toxicological studies.
CO 8	Identify and explain features of various fossils specimens.

DETAILED SYLLABUS

Paper IV - DSE

Course Code: RPSELScO604

Unit	Course/ Unit Title	Credits/ Hours
I	**Unit I: Environmental biology** **Ecosystems:** Types of ecosystems [terrestrial (Tropical evergreen forests, Tropical deciduous forests, Deserts, Chaparral, Temperate grasslands, Savannahs and thorn forests, Temperate deciduous forests, Boreal forests/ Taiga, Tundra) and aquatic (Lentic, Lotic, Oceans, Estuaries, Coral reefs)], Habitat fragmentation and niche overlap, Competitive exclusion principle, resource partitioning, character displacement and resource management and conservation. **Community ecology:** Nature of communities; fundamental properties of biological communities (Productivity, Diversity, Complexity, Resilience, Stability, Structure); levels of species diversity and its measurement (Simpson, Shannon and Sorensen indices); edges and ecotones, Succession, disturbances and invasion. Species interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis. **Population ecology:** Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation, demes and dispersal. **Toxicology:** Basic principles of toxicology including LD50 and ED50, management of acute intoxication.	1/ 15 Hrs
II	**Unit II: Current Environmental Issues in India and Biodiversity Management:** **Biodiversity:** Concept, characterization, generation, maintenance and loss, Magnitude and distribution of biodiversity, economic value, bioprospecting, ecotourism and biodiversity management approaches. Biodiversity of India. **Conservation biology:** Principles of conservation, major approaches to management, conservation strategies. **Forest Conservation –** Chipko movement, Appiko movement, Silent Valley movement and Gandhamardhan movement. People Biodiversity register. **Wild life conservation projects:** Project Tiger, Project Elephant, Crocodile Conservation, GOI-UNDP Sea Turtle project, Indo-Rhino vision. **Environmental issues related to water resource projects** - Narmada dam, Tehri dam, Almatti dam, Cauvery and Mahanadi, Hydro-power projects in Jammu & Kashmir, Himachal and North-Eastern States. **Water conservation**- Watersheds, Rain water harvesting and ground water recharge. **National river conservation plan** – Namami Gange and Yamuna Action Plan.	1/ 15 Hrs

	Eutrophication and restoration of lakes. Conservation of wetlands, Ramsar sites in India. **Soil erosion, desertification and Save Soil Movement.** **Climate change** - adaptability, energy security, food security and sustainability. Carbon sequestration and carbon credits. **Environmental Disasters:** Minnamata Disaster, Love Canal Disaster, Bhopal Gas Tragedy, 1984, Chernobyl Disaster, 1986, Fukusima Daiichi nuclear disaster, 2011. **Local environmental issues** – Mithi river pollution, Destruction of mangroves, Coastal aquafarming and challenges, Air quality index of Mumbai, Dumping grounds, Urban development projects at Aarey colony and Sanjay Gandhi National Park.	
III	**Unit III: Evolution and Astrobiology** **Emergence of evolutionary thoughts:** Lamarck; Darwin–concepts of variation, adaptation, struggle, fitness and natural selection; Types of selection; Speciation – Punctuated equilibrium and phyletic gradualism; Modern evolutionary synthesis. Origin of cells and unicellular evolution **Palaeontology and evolutionary history:** Introduction to time scales, origins of unicellular and multicellular organisms; major groups of plants and animals; Mass extinction events; Adaptive radiation, convergent evolution and coevolution; Primate evolution, Carbon dating, fossils. **Molecular Evolution:** Concepts of neutral evolution, molecular divergence and molecular clocks; origin of new genes and proteins; gene duplication and divergence, molecular taxonomy. **Astrobiology:** Concepts, planetary habitability, extremophiles, abiogenesis, research on surviving extreme habitats, evolution of advanced life, astrobiology of Mars.	**1/ 15 Hrs**

PRACTICALS: RPSELScPO604 (1 credit)

7. Analysing the floral origin of pollen grains in honey.
8. Determination of the Simpson's diversity index/ Shannon index of a given population.
9. Effect of toxicity on *Daphnia / C. elegans* / Yeast / Pollen grains and Probit analysis.
10. Effect of space vacuum/ cosmic radiation on bacteria.
11. Identification of fossil specimens.

References:

- The Cambridge Encyclopedia of Human Evolution (Cambridge Reference Book) by Steve Jones
- Evolution by Monroe W. Strickberger, CBS publishers and distributors
- Astrobiology: An Introduction by Alan Longstaff, CRC Press.
- Astrobiology: A brief introduction by Kevin W. Plaxco and Michael Gross, The Johns Hopkins University Press.
- Biodiversity, Wilson E.O. (Ed.), National Academy Press, Washington, D. C.
- Understanding Biodiversity by David Zeigler (May 30, 2007): Amazon Press
- Fundamentals of Ecology by E.P. Odum, Cengage publishers

- Ecology and environment by P.D. Sharma, Rastogi publications
- Elements of Ecology by Smith and Smith, Pearson publishers
- Environmental Biology edited by Mike Calver*et al*: Cambridge University Press
- Molecular Environmental Biology by Seymour J. Garte, Lewis Publishers (1994)
- Basic Environmental Toxicology, Lorris G. Cockerham& Barbara S. Shane, CRC Press.
- Environmental Toxicology, David Wright and Pamela Welbourn, Cambridge university press

DISCIPLINE SPECIFIC ELECTIVE COURSE offered by Department of Botany
Course Code: RPSEBOTO604
Course Title: Bioprospecting for Industrial Molecules

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION A student completing this course will be able to:
CO 1	Describe the role of entomotoxic proteins in crop protection.
CO 2	Enumerate the different extraction methods of natural sources for flavours and fragrances.
CO 3	Interpret the role of algae and plant products in bioprospecting.
CO 4	Comment on the economic potential of biological resources for obtaining industrial Molecules of pharmaceutical, bioceutical & agricultural value.
CO 5	Elaborate on the plant resources as antimicrobials by testing their antimicrobial activity.

RPSEBOTO604	Title: Bioprospecting for Industrial Molecules	Credits- 03
UNIT I	**Bioprospecting for crop protection and anti-microbial products**	**Hours- 15**
	• Introduction to Bioprospecting, its significance and recent trends in bioprospecting. • Entomotoxic proteins to control the crop insect pests and mechanism of insecticidal activity: • Lectins, Ribosome-Inactivating Proteins (RIPs), Arcelins, Defensins, Cyclotides (two examples of each) • Use of plant products as antimicrobials: Historical perspective. • Major groups of Plant-derived antimicrobial compounds: o Phenols and Phenolic acids, Terpenes and Essential oils, o Alkaloids (any two examples of each) • Mechanisms of Antimicrobial activity: o Plant extracts with efflux Pump Inhibitory Activity, Bacterial, Quorum Sensing Inhibitory Activity, Biofilm Inhibitory Activity.	
UNIT II	**Algal Biomass for high-value biomolecules**	**Hours- 15**
	Algae in high-value biomolecule production: • Polyphenols • Polysaccharides • Fatty acids • Pigments	
UNIT III	**Bioprospecting for flavours and fragrance**	**Hours- 15**
	Physiological mechanism of biosynthesis of essential oils: • Metabolic cycles of biosynthesis of Phenolic compounds. • Methods of extraction of natural sources for flavours andfragrances. • Designing of flavours and fragrance. • Sensory evaluation.	

PRACTICALS		
RPSEBOTPO604	Practicals based on **Bioprospecting for Industrial Molecules**	**Credit- 01**
1	Anti-microbial activity of plant extracts by disc diffusion method/ well diffusion method/ MIC method.	
2	Protein profiling by PAGE (seed proteins).	

3	Applications of proteins to control insect pests.
4	Fractional distillation of essential oils (mint/citronella/Chafa).
5	Creation of flavours & fragrances and practical demonstration.
6	Estimation of fragrance / flavours
7	Application of fragrances in cosmetics, food Agarbatti, Soap, Cream, Talcum Powder etc. Application of flavours in soft drink, tooth powder, jam, ketchup etc.

References:

1. Ramya Krishnan, Sudhir P. Singh, and Santosh Kumar Upadhyay. 2021. An introductionto Plant Biodiversity and Bioprospecting. Wiley Publications.

2. Surjeet Kumar Arya, Shatrughan Shiva, Santosh Kumar Upadhyay. 2021. Entomotoxic Proteins from Plant Biodiversity to Control the Crop Insect Pests. Wiley Publications.

3. Pankaj Kumar Verma, Shikha Verma, Nalini Pandey, and Debasis Chakrabarty. 2021.Antimicrobial products from plant Biodiversity. Wiley Publications.

4. Dinesh Kumar Yadav, Ananya Singh, Variyata Agrawal, Neelam Yadav. 2021. AlgalBiomass: A Natural Resource of High-Value Biomolecules. Wiley Publications.

5. Monica Butnariu. 2021. Plants as Source of Essential Oils and Perfumery Applications.Wiley Publication

Discipline Specific Elective Course offered by Department of Zoology

Course Code: RPSEZOOO604

Course Title: Introduction to Model organisms

COURSE OUTCOMES

COURSE OUTCOME	DESCRIPTION Upon successful completion of this course, learners will be able to;
CO 1	Enlist the different types of Hydras and its advantages as a model organism.
CO 2	Explain the Symbiotic association of *Hydra* with algae and Different types of cells in *Hydra*
CO 3	Summarise topics like Embryonic development, body axis formation, Larval stages, and metamorphosis and adult morphology of *Drosophila*.
CO 4	List the advantages of using *Drosophila* as a model organism.
CO 5	Differentiate male and female zebrafish and comprehend the developmental stages of zebrafish.
CO 6	Comprehend the importance of zebrafish as a versatile research and education model.
CO 7	Brief the anatomy and lifecycle of *Caenorhabditis elegans.*
CO 8	Perform the maintenance of Hydra, *Drosophila*, Zebrafish and C. elegans.

RPSEZOOO604	Title: Introduction to Model organisms	Credits 3
Unit: I	***Hydra & Drosophila*** • **Hydra as a model organism**: a) Introduction to *Hydra as a model system* b) Advantages of *Hydra* as model organism c) Different types of *Hydras* d) Basic requirement to set up *Hydra* system e) Symbiotic association of *Hydra* with algae f) Setting up Artemia hatchery (temperature, salinity, pH, lifecycle and nutritional value), g) *Hydra* regeneration, h) Different types of cells in *Hydra* • **Drosophila as a model organism**: a) Introduction to *Drosophila* as a model system b) Advantages of *Drosophila* as model organism c) Basic requirement to set up *Drosophila* lab d) Adult morphology e) Embryonic development f) Formation of body axis g) Larval stages and metamorphosis • Importance of *Hydra* & *Drosophila* as a versatile research and education model	
Unit: II	***Zebrafish*** • Introduction to zebrafish as model system • Advantages of zebrafish model organism • Basic requirement to set up zebrafish lab • Setting up zebrafish husbandry • To prepare zebrafish feed and culture *Paramecium* • Nutritional requirements • Handling zebrafish, identify male and female zebrafish • Breeding, Egg collection and study of developmental stages starting from the zygote - cleavage - blastula - gastrula - segmentation, pharyngula, hatching and early larval development. • Importance of zebrafish as a versatile research and education model. • Genetic and morphological homology with humans.	

Unit: III	***Caenorhabditis elegans*** • Introduction to *C. elegans* as model system • Anatomy of *C. elegans* • Lifecycle and different larval forms, • Advantages of *C. elegans* as model organism • Basic requirement to set up *C. elegans* system • Use of *C. elegans* as model system	
RPSEZOOPO604	**Practical Title: Introduction to Model organisms**	**Credit 1**
1.	*Hydra* media preparation.	
2.	Study of *Hydra* regeneration.	
3.	Setting up Artemia hatchery.	
4.	Culturing and maintaining *Drosophila*.	
5.	Study of life cycle and developmental stages of *Drosophila melanogaster.*	
6.	To study different mutants of *Drosophila.*	
7.	To setup zebrafish maintenance system.	
8.	Setting up breeding for zebrafish.	
9.	To study different behavioural patterns of zebra fish: Novel tank test, Mirror biting test, Predator avoidance, Light and dark test.	
10.	Culturing and maintaining *C. elegans.*	

References:

1. Lakhotia S. C. and Ranganath H. A. (2021) Experiments with Drosophila for Biology Courses, Indian Academy of Sciences, Bengaluru, India, ISBN: 978-81-950664-2-1
2. Sunita Joshi, S. and Dhamija, N. (2016) Rediscovering Genetics, IK International, 1st edition, ISBN: 9789384588984
3. Westerfield, M. (2000). The Zebrafish book. A guide for laboratory use of Zebrafish (Danio rerio). 4th ed., Univ. of Oregon Press, Eugene. USA
4. Mudgal, P., Bhasin, C., Joshi A., Gupta, R. (2021) Zebrafish, a versatile learning tool. Resonance: Journal of science education, 26(11), 1499-1521
5. Kimmel, C.B., Ballard, W.W., Kimmel, S.R., Ullmann, B. and Schilling, T.F. (1995), Stages of embryonic development of the zebrafish. Dev. Dyn., 203: 253-310. https://doi.org/10.1002/aja.1002030302
6. http;//www.zfic.org
7. Westerfield, M.; The zebrafish book; A guide for the laboratory use of zebrafish (Danio rerio) 4th edition (2000), University of Oregon Press, Eugene.

8. Hedges, S. B.; The origin and evolution of model organisms. Nat. Rev. Genet.3; 838- 849 (2002).
9. Grimmelikhuijzen, C.J.P. and Schaller, H. C.; "Hydra as a model organism for the study of morphogenesis." Trends in Biochemical Sciences 4, 12; 265-267 (1979).
10. Galliot, B.; Hydra, a fruitful model system for 270 years; International Journal of Developmental Biology, 56, 411-423 (2012).
11. Beckingham, K. M., Armstrong, J. D., Texada, M. J., Munjaal, R. and Baker, D. A.; Drosophila melanogaster : The model organism of choice for the complex biology of multi- cellular organisms. Gravitational and Space Research, 18(2) (2007).

PAPER V
Course Code: RPSRPLScO605
Course Title: Research Project (6 credits)

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION **At the end of the course students will be able to:**
CO 1	Develop strict norms of Good Laboratory Practices in their respective laboratories.
CO 2	Design and perform experiments, document results, perform statistical analyses and write their observations and conclusions independently.
CO 3	Organise their time and resources, and be resourceful in the absence of certain instruments or reagents.
CO 4	Learn to troubleshoot failed experiments and gain the ability to interpret both positive and negative results.
CO 5	Work independently as well as in pairs or groups by adopting the culture of inclusivity.
CO 6	Apply practical skills, experience and form networks with professionals in the institute/industry of their choice.
CO 7	Present their work in the form of oral or poster presentations at the national or international conferences or publish their work in research journals approved by the new UGC CARE list if deemed suitable by their research guides.

Modality of Assessment - DSC (Paper I, II, III) and DSE (Paper IV)

Theory Examination Pattern:

A) Internal Assessment 40% - 30 Marks

Sr No	Evaluation type	Marks
1	Class Test	20
2	Project / Assignment / Presentation	10
	TOTAL	**30**

B) External Examination (Semester End) 60%- 45 Marks

Semester End Theory Examination:

1. Duration – The duration for these examinations shall be of **two hours**.
2. Theory question paper pattern:

Paper Pattern:

Question	Options	Marks	Questions Based on
Q1	Q1 - A, B, C, D (3 questions of 5 M each from 4 Questions)	15	Unit 1
Q2	Q2 - A, B, C, D (3 questions of 5 M each from 4 Questions)	15	Unit 2
Q3	Q3 - A, B, C, D (3 questions of 5 M each from 4 Questions)	15	Unit 3
	TOTAL	**45**	

Practical Examination Pattern: 25 Marks

- Assessment of practicals only consists of External evaluation with a weightage of 50 marks.
- The pattern of the practical paper is as follows:

Semester	Papers	Question	Total marks
III	1, 2, 3, 4	Q1. Major experiment	15
		Q2. Identification	8
		Q3. Journal	2
Total marks			**25**

Modality of Assessment - Project work

Semester	Paper	Question	Total marks
III	RPSRPLScO605	Proposal writing, presentation with review article	25
		Project table work	80
		Thesis submission	25
		Final presentation & viva	20
Total marks			**150**

Overall Examination & Marks Distribution Pattern

Semester III

PAPER	EXAM	MARKS	GRAND TOTAL
I (100 marks) DSC	Theory	45	**550 marks**
	Internals	30	
	Practicals	25	
II (100 marks) DSC	Theory	45	
	Internals	30	
	Practicals	25	
III (100 marks) DSC	Theory	45	
	Internals	30	
	Practicals	25	
IV (100 marks) DSE	Theory	45	
	Internals	30	
	Practicals	25	
V (150 marks) Research Project	Project work & thesis Dissertation	100	
	Project Presentation & Viva	50	

M.Sc. Part - II Life Sciences Syllabus
Specialization - Biotechnology

SEMESTER IV

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	Hrs / WEEK
Paper I	**Medical Biotechnology**			
RPSLScE611 (Core Course)	I	Therapeutics	4	4
	II	Activity Guided Drug Development		4
	III	Pharmacogenomics and Drug design		4
Paper II	**Bioinformatics**			
RPSLScE612 (Core Course)	I	Introduction to Bioinformatics	4	4
	II	Alignment problem and solutions		4
	III	Genomics and Proteomics		4
Paper III	**Applied Biotechnology**			
RPSELScE613 (DSE)	I	Assisted Reproductive techniques	4	4
	II	Nanotechnology		4
	III	Diagnostics & Forensics		4
Paper IV	**Internship**			
RPSINTLScE614 (Core Course)		Internship	10	6

SEMESTER IV

PAPER I - Discipline Specific Core (DSC)
Course Code: RPSLScE611
Course Title: Medical Biotechnology

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION **At the end of the course students will be able to:**
CO 1	Describe the principles, classification, production and examples of therapeutic proteins.
CO 2	Summarize the various strategies and applications of antisense and gene therapy.
CO 3	Explain the important concepts in engineering of vaccines and peptibodies and their applications for various diseases.
CO 4	Evaluate disease models used for developing new therapeutics, and computational models for rational drug design.
CO 5	Describe the steps involved in drug designing right from identification of the API in activity guided drug development to its metabolism and action.
CO 6	Outline the pharmacogenomics of various illnesses like cancer syndromes, neuropsychotic and cardiovascular disorders.
CO 7	Analyse residual DNA in the given therapeutic protein samples.
CO 8	Compare phytochemical extraction methods, separation and visualisation using HPTLC technique and perform bioautography of plant extract and analyse its antimicrobial, antioxidant, anti-inflammatory and anti-larvicidal activity.

DETAILED SYLLABUS - Paper I

Course Code: RPSLScE611

Unit	Course/ Unit Title	Credits/ Lectures
I	**Unit I: Therapeutics** **Therapeutic Proteins**: Group I, II, III and IV and their applications in humans and animals, mode of action, stability, processing, and formulation. Examples of each class - Monoclonal Antibodies, vitamins, blood proteins, human hormones – Growth hormones, insulin, somatostatin, steroid hormones, immune modulators – factors VIII, IX, interferons and interleukins, erythropoietin, relaxin, epinephrine, TNF, tissue plasminogen activator protein and vaccines, glucagon, secretin, and antigens. **Gene and Antisense therapy:** Overview and examples **Genetic Engineering of Vaccines**: Identification and Cloning of Antigens with Vaccine Potential - DNA/Oligonucleotide Hybridization, Hybrid Selection and Cell-free Translation, Expression cloning and Genomic Sequencing, Analysis of Vaccine Antigens - B-cell Epitopes and T-cell Epitopes. Generation of Subunit Vaccines, Improvement and Generation of New Live Attenuated Vaccines - *Pseudorabies* Virus, *Vibrio* and *Poliovirus*, Recombinant Live Vectors - *Vaccinia* Virus, Recombinant BCG Vaccines, Attenuated *Salmonella* Strains, Poliovirus Chimaeras, Cross-species Vaccination, 'Live- dead' Vaccines, Other Virus Vectors and Recombinant *E. coli* Strains, DNA, RNA and peptide Vaccines, Anti-idiotypes, Enhancing Immunogenicity and modifying Immune Responses - Adjuvants, Carriers and Vehicles, Carriers, Mucosal Immunity, Modulation of Cytokine Profile, Modulation by Antigen Targeting and Modulation of Signaling. **Peptibodies**: Definition, peptide-Fc fusion, advantages over monoclonal antibodies, production in *E. coli* using recombinant DNA technology, production, and mechanism of action, applications – pain, ovarian cancer and immune thrombocytopenic purpura, limitations. **Peptidomimetics**: Definition, design, features, analysis, and application. **Biosimilars**: Definition, design, features, analysis, and application.	1/ 15L
II	**Unit II: Activity Guided Drug Development** **Plant collection and Extract preparations**: Methods of Plant collection, solvent extraction (cold, hot, critical fluid extraction etc), screening of medicinal properties; **Natural products**: methods of identification (Qualitative and Quantitative), isolation and purification (Chromatography), Characterization; **Bio efficacy studies**: *In vitro* testing- Antimicrobial, Antidiabetic, Antioxidant, Anti Inflammatory and Anti larvicidal activities. **Drug Development**: Introduction to the pharmaceutical industry, Natural drugs versus Synthetic drugs, Timeline of drug discovery, pharmacodynamics, plasma	1/ 15L

	concentration and Cp-time curves, ADME and pharmacokinetics, Drug dosing and therapeutic window. Lead discovery and Lead optimization, Prescribing information for drugs, pre-clinical and clinical trials, Regulatory approval. Disease Models in pharmaceutical research.	
III	**Unit III: Pharmacogenomics and Drug design** **Drug designing:** types of pharmacogenetic knowledge and obstacles, variations of drug metabolizers, transporters, drug targets and biological milieu of drug action, Target binding and drug potency. Population differences in drug effects. **Pharmacogenomics:** Cancer syndromes, neuropsychiatric disorders, Alzheimer's disease, mental retardation, cardiovascular diseases, smoking and alcoholism, Eugenics and epigenetics of above disorders, Genetic influences on drug targets involved in pharmacodynamics, long QT syndromes, emerging technologies.	**1/ 15L**

PRACTICALS: RPSLScPE611 (1 credit)

1. Residual DNA analysis of recombinant therapeutic protein.
2. Anti-larvicidal assay of a plant extract.
3. Comparison of phytochemical extraction methods.
4. Separation and visualisation of the components of a plant extract by HPTLC.
5. Bioautography for antimicrobial / antioxidant activity.
6. Anti-inflammatory/Anti-diabetic assay of a plant extract.

References:

1. Molecular Biology and Biotechnology, 4th edition (2002) by J. M. Walker and R. Rapley
2. Biotechnology by Rehm & Reed
3. Biotechnology, An Introduction (2008) by S. Ignacimuthu, S. J.
4. Biotechnology, Concepts and Applications (2009) by R. R. Vittal and R. Bhat
5. Biotechnology, Principles and Applications (2007) by S. C. Rastogi
6. Medical Biotechnology, Himalaya Publishing House, Mumbai, (2008) by Jogdand S. N.,
7. Medical Biotechnology, Churchill Livingstone, Elsevier (2009) by Judit Pongracz, Mary Keen
8. Medical Biotechnology, Oxford University Press (2010) by Pratibha Nallari & V. Venugopal Rao,
9. Therapeutic peptides and proteins by A. K. Banga
10. Plant Bioactives and Drug Discovery: Principles, Practice, and Perspectives 1st Edition Valdir Cechinel-Filho(Author), Wiley Publication.
11. Drug Discovery from Plants by Angela A. Salim, Young-Won Chin, A. Douglas Kinghorn (Springer publication)
12. Bioassay Methods in Natural Product Research and Drug Development by Lars Bohlin, Jan G. Bruhn (Springer Publication).

PAPER II - Discipline Specific Core (DSC)
Course Code: RPSLScE612
Course Title: Bioinformatics

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION **At the end of the course students will be able to:**
CO 1	Elaborate on the basics of computer operating system, internet and its components and internet sources.
CO 2	Classify the biological databases that are used in bioinformatics and select and use the appropriate biological database according to the query.
CO 3	Construct phylogenetic trees manually as well as computationally and explain the concepts, terminologies, types and properties of phylogenetic trees and the various methods of building it.
CO 4	Explain the concept of multiple or pairwise sequence alignment and select the appropriate software to carry out the alignment.
CO 5	Describe the concepts and list advanced tools used in the field of genomics and proteomics to give an overall perspective of complete molecular studies under one roof.
CO 6	Enlist various applications of drug designing.
CO 7	Perform *in silico* molecular docking, analyse protein binding site, protein-protein interactions and predict secondary structure using appropriate software tools.

DETAILED SYLLABUS - Paper II

Course Code: RPSLScE612

Unit	Course/ Unit Title	Credits/ Lectures
I	**Unit I: Introduction to Bioinformatics** Definition and History of Bioinformatics, Different Omics and its application and Current status. **Computers:** Operating systems, Internet and its components, Internet sources for Bioinformatics, Flat file. **Biological databases**: Classification, Primary DNA Databases, Primary and Secondary Protein Databases, Composite Structure Databases, UniProt, Protein Data Bank (PDB), Metabolism Database (KEGG).	1/ 15L
II	**Unit II: Alignment problem and solutions** **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, Neighbour-Joining Method, Maximum Parsimony.	1/ 15L
III	**Unit III: Genomics and Proteomics** **Genomics:** Basic concepts on genomics, Variant types, and classes, OMIM database, reference genome sequence, Genome browsers, Genome annotation, Gene expression profiling (GEO), Expressed sequence tags (ESTs), identification of disease genes, SNPs, SNP database (DbSNP), SNP arrays and GWAS. Gene disease pathway networks (GeDiPNet). **Techniques:** Sanger sequence analysis, Primer design, Restriction mapping. **Proteomics:** Introduction and 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	1/ 15L

	proteins of known structure, fundamental principles of protein folding etc.) Motif Finding. Homology Modelling (Ramchandran plot), fold recognition, threading approaches, and ab-initio structure prediction methods. Application in drug designing: Drug targets, Lead Identification and Modification, Computer-Aided Drug Design.	

PRACTICALS: RPSLScPE612 (1 credit)

1. Phylogenetic tree construction and analysis.
2. *In silico* molecular docking.
3. Sanger sequence analysis.
4. Primer designing.
5. Protein-protein interaction network analysis.

References:

1. Introduction to Bioinformatics- Attwood, Parry-Smith and Phukan
2. Bioinformatics: Sequence and Genome Analysis- David W. Mount
3. Bioinformatics and Functional Genomics- Jonathan Pevsner
4. Bioinformatics: Harshwardhan Pal

PAPER III – Discipline Specific Elective (DSE)
Course Code: RPSELScE613
Course Title: Applied Biotechnology

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION **At the end of the course students will be able to:**
CO 1	Explain the anatomy and physiology of male and female reproductive system and elaborate on causes and diagnosis of infertility.
CO 2	Describe the issues behind infertility, the physiology of reproduction, principles and techniques of ART, cryobiology and latest developments in the field.
CO 3	Classify nanostructures based on their structure and properties and explain the novel applications of this technology.
CO 4	Elaborate on various diagnostic techniques used in identifying genetic diseases, while considering their implications for disease screening and management.
CO 5	Analyse the role of forensics in crime scene investigation and evidence collection, examining techniques such as DNA fingerprinting, forensic anthropology, and drug identification, and evaluating their significance in legal proceedings.
CO 6	Apply the basics of forensic science to perform simple experiments like hair microscopy, separation of DNA using PAGE and analysing using silver staining and put their investigative and deducing skills to the test.
CO 7	Synthesize silver, zinc oxide and ferromagnetic nanoparticles in the laboratory and determine their biological activity.

DETAILED SYLLABUS - Paper III

Course Code: RPSELScE613

Unit	Course/ Unit Title	Credits/ Lectures
I	**Unit I: Assisted Reproductive Technology** **Introduction:** Male and female reproductive anatomy and physiology, the menstrual cycle, puberty, pregnancy. History of Assisted Reproductive Therapies (ART), Causes of infertility, testing and diagnosing infertility. **In Vitro Fertilization (IVF):** Stimulation protocols for IVF, Baseline assessment, sperm and egg culture, cryopreservation. Risks of IVF. **Other ARTs:** Preimplantation Genetic Screening/Diagnosis (PGS/D), Mitochondria replacement therapy (MRT), Assisted Zona Hatching (AZH). Fertilization using ICSI, embryonic culture at various stages of development, Grading embryos, **Transfer of embryos**- Direct embryo transfer, Zygote intrafallopian transfer (ZIFT).	1/ 15L
II	**Unit II: Nanotechnology** **Nanobiotechnology:** Concept. Types of nanostructures (Carbon nanostructures, nanoshells, dendrimers, quantum dots, nanowires, liposomes). Potential risks of Nanobiotechnology. **Synthesis of nanoparticles:** Physical, chemical and biological methods. **Applications of nanotechnology:** medicine and diagnostics (antimicrobial properties, therapies, drug delivery including rate programmed drug delivery, Microencapsulation of cells. imaging) agriculture, environment.	1/ 15L
III	**Unit III: Diagnostics and Forensics** **Diagnostics**: Inherited and non-inherited diseases, Direct Detection of Gene Mutations - Allele-specific Oligonucleotides and Restriction Enzyme Site Analysis, ARMS, Oligonucleotide Ligation, and Fluorescently Labelled DNA Sequencing; Indirect Diagnosis with Linked Genetic Markers, Cancer screening; F**orensics:** Crime-Scene Investigation and Evidence Collection, the Study of Hair, Pollen and Spore Examination, Fingerprints, Forensic Anthropology. Death: Meaning, Manner, Mechanism, Cause, and Time. DNA Fingerprinting: Markers MLP, SLP, mitochondrial DNA, Y chromosome analysis, X chromosome analysis. Blood and Blood Spatter, Drug Identification and Toxicology SNPs.	1/ 15L

PRACTICALS: RPSELScPE613 (1 credit)

1. Biological synthesis of silver/ zinc oxide nanoparticles and evaluation of its Antioxidant activity.
2. Preparation of gold nanoparticles/ ferromagnetic fluid/ corn flour non-Newtonian fluid
3. Antimicrobial activity of zinc oxide nanoparticles by the tetrazolium microplate assay.
4. Hair microscopy / fingerprint lifting for forensic analysis.
5. PAGE of DNA samples and silver staining.

References:

1. A Textbook of In Vitro Fertilization and Assisted Reproduction by Peter R. Brinsden (2005)
2. David K. Gardner, Ariel Weissman, Colin M. Howles, Zeev Shoham - Textbook of Assisted Reproductive Techniques, Fifth Edition, Volume 1 and 2, CRC Press (2018)
3. In-Vitro Fertilization, Third Edition by Kay Elder, Brian Dale - (2011, Cambridge University Press)
4. Bio - Nanotechnology by Madhuri Sharon.
5. Molecular Biology and Biotechnology, 4th edition (2002) by J. M. Walker and R. Rapley
6. Microfluidics for Biotechnology 2nd Edition by Jean Berthier and Pascal Silberzan
7. Introduction to microfluidics by Patrick Tabeling
8. Forensic Science: Fundamentals and Investigations, by Anthony J Bertino - Cengage Learning (2011).
9. Fundamentals of Forensic Science by Siegel, Jay A. Houck, Max M - 3rd Edition, Elsevier, Academic Press (2006).

PAPER IV

Course Code: RPSINTLScE614

Course Title: Internship (10 credits)

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION **At the end of the course students will be able to:**
CO 1	Develop strict norms of Good Laboratory Practices in their respective laboratories.
CO 2	Design and perform experiments, document results, perform statistical analyses and write their observations and conclusions independently.
CO 3	Organise their time and resources, and be resourceful in the absence of certain instruments or reagents.
CO 4	Learn to troubleshoot failed experiments and interpret both positive and negative results.
CO 5	Work independently as well as in pairs or groups by adopting the culture of inclusivity.
CO 6	Apply practical skills, experience and form networks with professionals in the institute/industry of their choice.
CO 7	Present their work in the form of oral or poster presentations at the national or international conferences or publish their work in research journals approved by the new UGC CARE list if deemed suitable by their research guides.

Modality of Assessment - DSC (Paper I, II) and DSE (Paper III)

Theory Examination Pattern:

C) Internal Assessment 40% - 30 Marks

Sr No	Evaluation type	Marks
1	Class Test	20
2	Project / Assignment / Presentation	10
	TOTAL	**30**

D) External Examination (Semester End) 60%- 45 Marks

Semester End Theory Examination:

3. Duration – The duration for these examinations shall be of **two hours**.
4. Theory question paper pattern:

Paper Pattern:

Question	Options	Marks	Questions Based on
Q1	Q1 - A, B, C, D (3 questions of 5 M each from 4 Questions)	15	Unit 1
Q2	Q2 - A, B, C, D (3 questions of 5 M each from 4 Questions)	15	Unit 2
Q3	Q3 - A, B, C, D (3 questions of 5 M each from 4 Questions)	15	Unit 3
	TOTAL	**45**	

Practical Examination Pattern: 25 Marks

- Assessment of practicals only consists of External evaluation with a weightage of 25 marks.
- The pattern of the practical paper is as follows:

Semester	Papers	Question	Total marks
IV	1, 2, 3	Q1. Major experiment	15
		Q2. Identification	8
		Q3. Journal	2
Total marks			**25**

Modality of Assessment – Internship

Semester	Paper	Question	Total marks
IV	RPSINTLScE614	Internship daily report from mentor	10
		Internship table work (by mentor)	190
		Thesis submission	30
		Final Presentation & viva	20
Total marks			**250**

Overall Examination & Marks Distribution Pattern

Semester IV

PAPER	EXAM	MARKS	GRAND TOTAL
I (100 marks) DSC	Theory	45	**550 marks**
	Internals	30	
	Practicals	25	
II (100 marks) DSC	Theory	45	
	Internals	30	
	Practicals	25	
III (100 marks) DSE	Theory	45	
	Internals	30	
	Practicals	25	
IV (250 marks)	Internship (lab guide/mentor)	200	
	Thesis & viva (Dept)	50	

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