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S. P. Mandali's
Ramnarain Ruia Autonomous College



Syllabus for Masters of Science

Program: M.Sc. Life Science

Program Code: RPSLSc

(NEP2020 - Choice Based Credit System for the
academic year 2023–2024)

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.

The third semester is designed to further the knowledge of the students in the specialization of Biotechnology. Diverse topics like Environmental biotechnology, Bioinformatics, Advanced protein studies as well as Biomathematics are focused on. The elective involves promising areas of Applied Biotechnology like Assisted Reproductive Technologies, Microfluidics and Nanotechnology. 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 tissue culture and fermentation technology. The students will also be exposed to the fundamentals of the Pharmaceutical and Medical biotechnology industries and the novel areas of research involved in it. They can also opt for the elective which includes other Applied Biotechnology areas like Diagnostics, Forensics and Regenerative Medicine. 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.

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PROGRAM OUTLINE

YEAR	SEM	COURSE CODE	COURSE TITLE	CREDITS	
2023-24	I	RPSLSc.O501 (Core Course)	Molecular Biology	4	
	I	RPSLSc.O502 (Core Course)	Biochemical Studies	4	
	I	RPSLSc.O503 (Core Course)	Bioanalytical Techniques and IPR	4	
	I	RPSLSc.O504 (Core Course)	Cellular processes	2	
	I	RPSRMLSc.O505 (RM)	Research Methodology and Scientific writing	4	
	I	RPSLSc.O506 (DSE)	Environmental Biology, Biodiversity and Evolution	4	
	II	RPSLSc.E511 (Core Course)	Plant Physiology and Model Organisms	4	
	II	RPSLSc.E512 (Core Course)	Life Processes	4	
	II	RPSLSc.E513 (Core Course)	Genetic Manipulation and Cell Signalling	4	
	II	RPSLSc.E514 (Core Course)	Microbiology and Immunology	2	
	II	RPSLSc.E515 (FP)	Field Project	4	
	II	RPSLSc.E516 (DSE)	Genetic Engineering	4	
	Total Credits				44

2023-24	III	RPSLSc301	Fermentation Technology and Tissue Culture	6
	III	RPSLSc302	Applied Biotechnology	6
	III	RPSLSc303	Bioinformatics, International Standards and Bioethics	4
	III	RPSLSc304	Internship / Project Work	8
	IV	RPSLSc401	Medical Biotechnology	6
	IV	RPSLSc402	Environmental Biotechnology	6
	IV	RPSLSc403	Protein studies and Biomathematics	6
	IV	RPSLSc404	Project Work	6
Total Credits				48

- 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			
RPSLSc.O501 (Core Course)	I	Genetics	4	4
	II	DNA Replication, Repair & Recombination		4
	III	Transcription and Translation		4
Paper II	Biochemical studies			
RPSLSc.O502 (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			
RPSLSc.O503 (Core Course)	I	Instrumentation I	4	4
	II	Instrumentation II		4
	III	IKS and IPR		4
Paper IV	Cellular processes			
RPSLSc.O504 (Core Course)	I	Cell biology	2	4
	II	Photosynthesis, Mitochondrial and Chloroplast Electron Transport Chain		4
Paper V	Research Methodology and Scientific Writing			
RPSRMLSc.O 505 (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			
RPSLSc.O506	I	Environmental biology	4	4

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

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SEMESTER I

PAPER I – Discipline Specific Core (DSC)

Course Code: RPSLSc.O501

Course Title: Molecular Biology

COURSE OUTCOMES:

This paper provides a great combination of cellular components, molecular level studies in a cell and the inheritance pattern as these interlinked topics would clear student's concepts.

COURSE OUTCOME	DESCRIPTION At the end of the course students will be able to:
CO 1	Understand basic in-depth fundamentals of cellular structure, components, and their functions. 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 2	Recall the detailed events of one of the highly coordinated processes of the cell cycle, its role, regulation, and checkpoints.
CO 3	Employ gene mapping methods to find the distance between genes.
CO 4	Compare the mechanisms involved in DNA replication, recombination and repair in prokaryotes and eukaryotes.
CO 5	Appraise the concepts of the central dogma of life from DNA to RNA to proteins which serve the whole purpose of molecular biology.
CO 6	Employ creative media in assignments to express the concepts learnt.

DETAILED SYLLABUS - Paper I

Course Code: RPSLSc.O501

Unit	Course/ Unit Title	Credits/ Hours
I	<p><u>Unit I: Genetics:</u> 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.</p>	1/ 15hrs
II	<p><u>Unit II: DNA Replication, Repair and Recombination</u></p> <p>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.</p>	1/ 15hrs
III	<p><u>Unit III: Transcription and Translation</u></p> <p>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.</p>	1/ 15hrs

	<p>The Genetic Code: The Decoding System, Codon -Anticodon interaction.</p> <p>Ribosomes: the special properties of the prokaryotic and eukaryotic ribosomes, ribosome biogenesis.</p> <p>Translation process: initiation, elongation and termination factors of prokaryotes and eukaryotes mechanisms to overcome premature translation termination, role of suppressor tRNAs.</p> <p>Inhibitors of protein synthesis: Prokaryotic and eukaryotic protein synthesis inhibitors and their significance.</p>	
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PRACTICALS: RPSLScP.O501 (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: RPSLSc.O502

Course Title: Biochemical Studies

COURSE OUTCOMES:

Biomolecules are the basis of life and this paper is dedicated to these biochemical aspects which includes knowing the structure and functions of certain basic biomolecules and the pathways / mechanisms for food and energy production.

COURSE OUTCOME	DESCRIPTION
	At the end of the course students will be able to:
CO 1	Investigate the unique properties of amino acids which influences the amazing diversity of proteins.
CO 2	Relate the basic concepts in protein biochemistry to advanced subjects like protein engineering, vaccine formulation and drug designing.
CO 3	Understand the structure and properties of lipids and their role in our diet.
CO 4	Recall the classification, structural properties of carbohydrates along with the concept of stereochemistry and biological roles.
CO 5	Evaluate the structure, and role of vitamins and minerals and explain their importance with respect to nutritional deficiencies.
CO 6	Construct the graphs depicting enzyme kinetics.

DETAILED SYLLABUS - Paper II

Course Code: RPSLSc.O502

Unit	Course/ Unit Title	Credits/ Hours
I	<p><u>Unit I: Protein and Lipids</u></p> <p>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.</p> <p>Lipids: structure, nomenclature, classification and properties of lipids, lipid assembly, model membranes, formation of liposomes and drug targeting.</p>	1/ 15hrs
II	<p><u>Unit II: Carbohydrates, Vitamins, and Minerals</u></p> <p>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.</p> <p>Vitamins: Structure and biological roles of water soluble and lipid soluble vitamins, vitaminosis and deficiency.</p> <p>Minerals: Structure and biological roles of bulk and trace elements.</p>	1/ 15hrs
III	<p><u>Unit III: Enzymology and Enzymes in Industry</u></p> <p>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.</p> <p>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.</p> <p>Industries: Textile Processing, Leather Processing, Paper & Pulp Processing, Detergents, and laundry.</p> <p>Food biotechnology: Fruit and vegetable processing: juices, nectars, purees; syrup and glucose isomerases, enzymatic synthesis of aspartame.</p> <p>Feed Biotechnology: lignocelluloses into feed using cellulases, silage.</p> <p>Other industrial uses: Vinegar, Baking, Cocoa fermentation, Olive oil production, fish processing industries.</p>	1/ 15hrs

PRACTICALS: RPSLScP.O502 (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 K_m and V_{max} 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: RPSLSc.O503
Course Title: Bioanalytical Techniques and IPR

COURSE OUTCOMES:

Students will develop a comprehensive understanding of the principles, techniques, and applications of instrumentation, spectroscopy, PCR, chromatography and IPR. They will be equipped with the knowledge and skills necessary to apply these concepts in biological research, analysis, and intellectual property protection.

COURSE OUTCOME	DESCRIPTION
	Upon successful completion of this course, learners will be able to;
CO 1	Illustrate the basic principles, working and applications of chromatography.
CO 2	Develop a deeper understanding of different forms of IPR's, procedures and the process of patent filing.
CO 3	Understand the principles, instrumentation, and working of various microscopy techniques such as fluorescence microscopy, polarization microscopy, phase contrast microscopy, TEM, and SEM. Explore their applications in biological research.
CO 4	Comprehend the principle of PCR (Polymerase Chain Reaction) and its steps. Recognize the constraints and limitations of PCR and explore the modifications of PCR techniques. Understand the wide range of applications of PCR in various fields of biological research.
CO 5	Gain knowledge of different spectroscopy techniques, including IR, GC-MS, LC-MS, AAS, ICP-AES, plasma emission spectroscopy, NMR, and 2D NMR. Learn their principles, instrumentation, and applications in biological and chemical analysis.
CO 6	Gain insights into the protection of traditional knowledge, geographical indications, industrial designs, gene patenting, plant variety protection, and trade secrets.

DETAILED SYLLABUS - Paper III

Course Code: RPSLSc.O503

Unit	Course/ Unit Title	Credits/ Hours
I	<p><u>Unit I: Instrumentation I</u> 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.</p>	1/ 15hrs
II	<p><u>Unit II: Instrumentation II</u> 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.</p>	1/ 15hrs
III	<p><u>Unit III: IKS and IPR</u> 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.</p>	1/ 15hrs

PRACTICALS: RPSLScP.O503 (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 cytochemistry
- 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: RPSLSc.O504
Course Title: Cellular processes

COURSE OUTCOMES:

This paper explores the cellular components and processes in a cell.

COURSE OUTCOME	DESCRIPTION
	At the end of the course students will be able to:
CO 1	Demonstrate a comprehensive understanding of the structure, composition, and functions of various cell organelles.
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	Recall 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 CO ₂ fixation by the C ₃ , C ₄ , and CAM pathways, and understand 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	Understand 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 F ₀ F ₁ ATPase complex. Evaluate different theories of ATP synthesis and their implications.

DETAILED SYLLABUS - Paper IV

Course Code: RPSLSc.O504

Unit	Course/ Unit Title	Credits/ Hours
I	<p><u>Unit I: Cell Biology</u></p> <p>Plasma membrane: Structure and composition, Membrane properties, Functions and Membrane models.</p> <p>Endoplasmic reticulum: Structure and function of Rough and smooth ER.</p> <p>Golgi complex: Structure and function, Cisternal progression theories.</p> <p>Nucleus: Structure - Nuclear envelope, Nuclear pore complex & Nuclear lamin proteins, Functions, Chromatin - Heterochromatin, Euchromatin, Packaging and models. Nucleolus - Structure and function.</p> <p>Other organelles: Lysosomes, peroxisomes, mitochondria, chloroplasts, and vacuoles.</p> <p>Cytoskeleton: Structure, Assembly & Functions of Microtubules, Intermediate filaments (types) & Microfilaments.</p> <p>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).</p> <p>Checkpoints (unreplicated DNA, spindle attachment, segregation of chromosomes, DNA Damage)</p> <p>Concept of cyclin and CDKs; activation of the cyclin-CDK complexes (Yeast / Mammalian).</p> <p>G₁ cyclins: Cln1, Cln2 and Cln3 and its relevance in commitment to cell division.</p> <p>S phase and G₂ phase: S phase cyclin, its inhibitors and pre-replication complex and its significance in DNA replication in the cell cycle.</p> <p>M phase: Prophase, Metaphase, Anaphase and Telophase, condensins, securin, separase and the end of mitosis.</p> <p>Meiosis checkpoints (Ime2, Rec8 and monopolin)</p>	1/ 15hrs
II	<p><u>Unit II: Photosynthesis, Mitochondrial & Chloroplast Electron Transport Chain</u></p> <p>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.</p> <p>Mitochondrial ETC: structure and function of mitochondrial ETC proteins and mechanism of oxidative phosphorylation, F₀ F₁ ATPase, theories of ATP synthesis.</p>	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.

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PAPER V

Course Code: RPSRMLSc.O505

Course Title: Research Methodology and Scientific Writing

Course Description:

Research is a field that requires the ability to plan and conduct experiments, deduce results and document the outcomes. It also involves exhaustive troubleshooting, dissemination of the results, managing interpersonal relationships and following several ethical norms. This paper aims to inculcate these abilities in the students so that they may successfully conduct their project work/ internship / future careers in the field of scientific research.

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.
CO 3	Make use of methods of data collection, 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.

Detailed Syllabus Paper V – Research Methodology

Course code: RPSRMLSc.O505

Unit	Course/ Unit Title	Credits / Hours
I	<p><u>Unit I - Research Methodology-I</u></p> <p>Introduction: Research design principles, execution of work, interpretation of results.</p> <p>Review of literature</p> <p>Library: Structure of a scientific library, journals, books, Digital library and E books</p> <p>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.</p> <p>Preparation of index cards: Author index and subject index; Open source, bibliography management system</p> <p>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.</p> <p>Interpersonal abilities: Networking, Conflict resolution.</p>	1/ 15hrs
II	<p><u>Unit II - Scientific Writing</u></p> <p>Introduction to scientific writing: Meaning of Scientific and non-scientific writing; Scientific Vocabulary and grammar. Synopsis, Dissertations, Thesis, Posters.</p> <p>Correspondence: Formal letters, cover letters, drafting emails, replying to reviewers.</p> <p>Writing a Research paper: Title, Abstract, Introduction, Review of literature, Methodology, Observations, Results, Discussions, Summary, Conclusion, and Bibliography (Referencing and citation styles). Supplementary data.</p> <p>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.</p> <p>Bioethics: Definition – moral, values, ethics and ethics in biology; Role and importance of ethics in biology; Legal and regulatory issues; Bioethics in healthcare, agriculture, modern biology, biotechnology, animal welfare & right / animals in research, wildlife conservation and management, commercialism in scientific research.</p> <p>Scientific misconduct: Plagiarism, Fabrication, Authorship conflicts, Salami and imalas publication.</p>	1/ 15hrs

III	<p><u>Unit III: Use of Software in Research</u></p> <p>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.</p>	1/ 15hrs
IV	<p><u>Unit IV: Biostatistics</u></p> <p>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).</p>	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: RPSLSc.O506
Course Title: Environmental Biology, Biodiversity and Evolution

COURSE OUTCOMES:

This course covers a wide range of topics in environmental biology, including ecosystems, community ecology, population ecology, toxicology, biodiversity management, and evolution. Students will gain a comprehensive understanding of these subjects as well as the significance of space exploration and astrobiology.

COURSE OUTCOME	DESCRIPTION
	At the end of the course students will be able to:
CO 1	Understand 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	Explore the magnitude and distribution of biodiversity and its economic value. Gain insights into 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	Develop a comprehensive understanding of astrobiology, including the concepts of planetary habitability, extremophiles, abiogenesis, research on surviving extreme habitats, evolution of advanced life, and the astrobiology of Mars.

DETAILED SYLLABUS – Paper VI - DSE

Course Code/ Unit: RPSLSc.O506

Unit	Course/ Unit Title	Credits/ Hours
I	<p><u>Unit I: Environmental biology</u></p> <p>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.</p> <p>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.</p> <p>Population ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation, demes and dispersal.</p> <p>Toxicology: Basic principles of toxicology including LD50 and ED50, management of acute intoxication.</p>	1/ 15hrs
II	<p><u>Unit II: Current Environmental Issues in India and Biodiversity Management:</u></p> <p>Biodiversity: Concept, characterization, generation, maintenance and loss, Magnitude and distribution of biodiversity, economic value, bioprospecting, ecotourism and biodiversity management approaches. Biodiversity of India.</p> <p>Conservation biology: Principles of conservation, major approaches to management, conservation strategies.</p> <p>Forest Conservation – Chipko movement, Appiko movement, Silent Valley movement and Gandhamardhan movement. People Biodiversity register.</p> <p>Wild life conservation projects: Project Tiger, Project Elephant, Crocodile Conservation, GOI-UNDP Sea Turtle project, Indo-Rhino vision.</p> <p>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.</p> <p>Water conservation- Watersheds, Rain water harvesting and ground water recharge.</p> <p>National river conservation plan – Namami Gange and Yamuna Action Plan.</p>	1/ 15hrs

	<p>Eutrophication and restoration of lakes. Conservation of wetlands, Ramsar sites in India.</p> <p>Soil erosion, desertification and Save Soil Movement.</p> <p>Climate change - adaptability, energy security, food security and sustainability. Carbon sequestration and carbon credits.</p> <p>Environmental Disasters: Minnamata Disaster, Love Canal Disaster, Bhopal Gas Tragedy, 1984, Chernobyl Disaster, 1986, Fukushima Daiichi nuclear disaster, 2011.</p> <p>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.</p>	
III	<p><u>Unit III: Evolution and Astrobiology</u></p> <p>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</p> <p>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.</p> <p>Molecular Evolution: Concepts of neutral evolution, molecular divergence and molecular clocks; origin of new genes and proteins; gene duplication and divergence, molecular taxonomy.</p> <p>Astrobiology: Concepts, planetary habitability, extremophiles, abiogenesis, research on surviving extreme habitats, evolution of advanced life, astrobiology of Mars.</p>	1/ 15hrs

PRACTICALS: RPSLScP.O506 (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

Ramnarain Ruia Autonomous College

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: 50 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
I	1, 2, 3, 6	Q1. Major experiment	30
		Q2. Identification	10
		Q3. <i>Viva voce</i>	5
		Q4. Journal	5
Total marks			50

Overall Examination & Marks Distribution Pattern

Semester I

PAPER	EXAM	MARKS	GRAND TOTAL
I (125 marks) DSC	Theory	45	650 marks
	Internal	30	
	Practical	50	
II (125 marks) DSC	Theory	45	
	Internal	30	
	Practical	50	
III (125 marks) DSC	Theory	45	
	Internal	30	
	Practical	50	
IV (50 marks) DSC	Theory	50	
V (100 marks) RM	Theory	60	
	Internal	40	
VI (125 marks) DSE	Theory	45	
	Internal	30	
	Practical	50	

SEMESTER II

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	L / WEEK
Paper I	Plant Physiology and Model Organisms			
RPSLSc.E511 (Core Course)	I	Plant Physiology I	4	4
	II	Plant Physiology II		4
	III	Model Organisms		4
Paper II	Life Processes			
RPSLSc.E512 (Core Course)	I	Animal Physiology	4	4
	II	Developmental Biology		4
	III	Neurobiology		4
Paper III	Genetic Manipulation and Cell Signalling			
RPSLSc.E513 (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			
RPSLSc.E514 (Core Course)	I	Microbiology	2	4
	II	Immunology		4
Paper V	Field Project			
RPSLSc.E515 (FP)	Field Project		4	4
Paper VI	Genetic Engineering			
RPSLSc.E516 (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: RPSLSc.E511

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	Appreciate how plants see the world through photoreceptors and their responses to abiotic and biotic stresses.
CO 2	Gain an insight on plant development and plant cell death.
CO 3	Understand the responses of plants to abiotic stress, such as water, salt, and temperature, and explore the mechanisms of plant defense against biotic stress, including viral, fungal, and insect attacks.
CO 4	Appraise the different biochemical and signalling pathways for plant hormones.
CO 5	Culture and maintain certain animal model organisms.
CO 6	Choose an appropriate plant model system depending on a research objective.

DETAILED SYLLABUS - Paper I

Course Code: RPSLSc.E511

Unit	Course/ Unit Title	Credits/ Hours
I	<p><u>Unit I: Plant Physiology I</u> 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).</p>	1/ 15hrs
II	<p><u>Unit II: Plant physiology II</u> 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 <i>Arabidopsis</i> and <i>Antirrhinum</i>. 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.</p>	1/ 15hrs
III	<p><u>Unit III: Model Organisms</u> Nematode worm (<i>Caenorhabditis elegans</i>) - History and description of the model. Culturing and maintenance. Research tools – Wormbase, WORMATLAS, Validation of target molecules in <i>C. elegans</i> (genome-wide RNAi, knockouts, compound libraries, HTS and the MOA strategy) Fruit fly (<i>Drosophila melanogaster</i>) - 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 (<i>Xenopus tropicalis</i>) - Trans-NIH Xenopus Initiative, Xenbase Mouse (<i>Mus musculus</i>) - Model organism for mammalian physiology, Types used for research, The Mouse Knockout & Mutation database. Zebrafish (<i>Danio rerio</i>) - Model organism to study vertebrate physiology and</p>	1/ 15hrs

	development. Culturing and maintenance. Research tools- Genetic screens with morpholino's. Zebra fish assays. ZFIN database Plant model systems: <i>Arabidopsis thaliana</i> , <i>Zea mays</i> , <i>Physcomitrella patens</i> , <i>Medicago truncatula</i> , <i>Populus trichocarpa</i> , <i>Oryza sativa</i>	
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PRACTICALS: RPSLScP.E511 (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: RPSLSc.E512
Course Title: Life processes

COURSE OUTCOMES:

This paper involves the study of higher organisms including animal physiology, developmental biology, and neurobiology.

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	Examine the disorders arising from defects in physiological processes in humans.
CO 3	Correlate various developmental processes in an organism by understanding the important fundamental concepts of development like commitment, specifications, determination, and differentiations with examples.
CO 4	Gain in-depth knowledge on the concepts of gametogenesis, fertilization, and formation of germ layers during early development processes.
CO 5	Understand the basics of neuroanatomy and neurocellular mechanisms like electrical & chemical signaling and neurotransmission as well as the advanced functions of the nervous system such as the sensory systems, motor and movement control, behaviour, emotions, learning, memory, and pain
CO 6	Evaluate the interplay between neural and chemical regulation in controlling and maintaining homeostasis within animal physiology, and recognize the significance of hormonal balance in normal physiological functioning and the consequences of hormonal disorders.

DETAILED SYLLABUS - Paper II - Core Course

Course Code: RPSLSc.E512

Unit	Course/ Unit Title	Credits/ Hours
I	<p><u>Unit I: Animal Physiology:</u></p> <p>Vascular system: Blood corpuscles, haematopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin, immunity, haemostasis.</p> <p>Cardiovascular System: Comparative anatomy of heart structure, cardiac tissue, cardiac cycle, blood pressure, neural and chemical regulation.</p> <p>Respiratory system: Comparative anatomy, transport and exchange of gases, neural and chemical regulation.</p> <p>Digestive system: Comparative anatomy, human digestive system, Diet and BMR.</p> <p>Excretory system: Comparative physiology, human excretory system, osmoregulation.</p> <p>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.</p> <p>Thermoregulation: Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization.</p> <p>Stress and adaptation</p>	1/ 15hrs
II	<p><u>Unit II: Developmental biology</u></p> <p>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.</p> <p>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.</p> <p>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.</p>	1/ 15hrs
III	<p><u>Unit III: Neurobiology</u></p> <p>Overview: central nervous system (CNS) and peripheral nervous system (PNS)- structure, organization, and function</p> <p>Cellular perspective: types of cells and function</p> <p>Impulse generation and conduction of nerve impulse</p> <p>Synaptic transmission: Electrical and Chemical with examples of two</p>	1/ 15hrs

	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.	
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PRACTICALS: RPSLScP.E512 (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 Edition)
- Developmental Biology: Mohan and Arora.

PAPER III - Discipline Specific Core (DSC)
Course Code: RPSLSc.E513
Course Title: Genetic Manipulation and Cell signalling

COURSE OUTCOMES:

This paper comprises advanced topics in molecular biology which deals with the regulation of gene expression with insights to the introduction to genetic engineering and cell communication and signalling processes.

COURSE OUTCOME	DESCRIPTION
	At the end of the course students will be able to:
CO 1	Compare the mechanisms of gene expression as well as the components involved in gene regulation between prokaryotes and eukaryotes.
CO 2	Understand the post transcriptional and post translational modifications along with the role of numerous factors involved in both the processes.
CO 3	Appraise the various tools used for genetic engineering like restriction enzymes and vectors
CO 4	Apply the concepts of Transformation, Transfection and Transduction methods used for introducing recombinant genes into various host organisms.
CO 5	Classify the distinct types of cellular signalling, receptors and signalling pathways as well as apoptosis pathways.
CO 6	Formulate cancer treatment strategies based on the knowledge of cancer physiology.

DETAILED SYLLABUS - Paper III

Course Code: RPSLSc.E513

Unit	Course/ Unit Title	Credits/ Hours
I	<p><u>Unit I: Gene and Gene Cloning:</u></p> <p>Structure of Gene: Monocistronic and Polycistronic, Promoter, Operator, ORF, Terminator, Gene families, Pseudogenes, Split Gene.</p> <p>Other elements of Eukaryotic Genome: Satellite DNA, Tandem repeat array, Transposons: LINE and SINE.</p> <p>Genomic Mutations: Introduction, Deletions, Addition, Insertion, Inversions and Translocations.</p> <p>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.</p> <p>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.</p>	1/ 15hrs
II	<p><u>Unit II: Gene Expression Regulation and Epigenetics:</u></p> <p>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.</p> <p>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.</p> <p>Epigenetics: Histones, Non-Histones, Scaffolding proteins. Hypothesis, Imprinting, Mechanism (Methylation and Acetylation), Cancer epigenetics, Anticipation, Penetrance and Expressivity.</p>	1/ 15hrs

III	<p><u>Unit III: Cell communication and signalling in normal cells and cancer cells</u></p> <p>Receptor ligand dynamics, nuclear receptors, Cell surface receptors, second messengers and regulation of the signalling pathway.</p> <p>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.</p> <p>Extracellular matrix: Fibres, cell adhesion molecules and their functions, gap junctions.</p> <p>Apoptosis: Concept of programmed cell death, Comparison with necrosis, Extrinsic and intrinsic pathways of apoptosis, detection of apoptotic cells.</p> <p>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.</p>	1/ 15hrs
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PRACTICALS: RPSLScP.E513 (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: RPSLSc.E514
Course Title: Microbiology and Immunology

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
	At the end of the course students will be able to:
CO 1	Develop a comprehensive understanding of microbial diversity along with their classification.
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	Gain knowledge of antibiotics, including their classification, mode of action, and resistance mechanisms, and understand the characteristics of antifungal and antiviral drugs.
CO 4	Explore the host-parasite interaction, including the mechanisms of microbial pathogenicity and disease establishment by different pathogens in animal hosts.
CO 5	Understand 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	Gain knowledge about the 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: RPSLSc.E514

Unit	Course/ Unit Title	Credits/ Hours
I	<p>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.</p>	1/ 15hrs
II	<p>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.</p>	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: RPSLSc.E515

Course Title: Field Project (4 credits)

COURSE OUTCOMES:

By successfully completing this course, students will develop a strong foundation in fieldwork involving model organisms, enabling them to apply their knowledge and skills in ecological research, conservation, and other areas of biological sciences that rely on field-based investigations.

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: RPSLSc.E516
Course Title: Genetic Engineering

COURSE OUTCOMES:

This entire paper deals with the several recombinant techniques that are currently used in the genetic engineering field and various comparative expression systems among prokaryotes & eukaryotes that have been successfully developed. It gives a complete picture to students where they learn these recombinant techniques as well as their applications in the form of these expression systems.

COURSE OUTCOME	DESCRIPTION At the end of the course students will be able to:
CO 1	Understand the detailed mechanisms of various recombinant techniques & latest gene editing tools such as CRISPR/Cas.
CO 2	Acquire knowledge to use novel reporter systems, metabolic engineering aspects, in-silico modelling, and Omics analysis.
CO 3	Recognise 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.

DETAILED SYLLABUS

Paper VI - DSE

Course Code: RPSLSc.E516

Unit	Course/ Unit Title	Credits/ Hours
I	<p>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: Homologous 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 – <i>E. coli</i>, <i>B. subtilis</i>, <i>Saccharomyces</i>, Industrial applications.</p>	1/ 15hrs
II	<p>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: <i>Bacillus subtilis</i>, <i>Lactobacilli</i>, <i>Streptomyces</i> – Expression systems, optimization of expression and applications.</p>	1/ 15hrs
III	<p>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 (<i>Aspergillus</i>, etc.), applications - pharmaceutically important secondary metabolites, medicinal mushrooms (<i>Ganoderma</i>, etc.), polysaccharides from basidiomycetes for immunostimulatory and anticancer activity. Yeasts: Yeast Selectable Markers and Vector Systems, commercially used yeast</p>	1/ 15hrs

	<p>strains (<i>S. cerevisiae</i> and <i>Pichia</i>) and their expression systems.</p> <p>Heterologous Protein Production - Design parameters: Source of DNA, Heterologous mRNA and protein levels and downstream applications, humanization of yeast for post translational compatibility.</p> <p>Uses: YAC Technology, Constructing Gene Knockouts and Novel Reporter Systems, synthesis of commercially important compounds.</p> <p>Protozoa: Advantages of protozoan expression systems, cultivation and applications of protozoan biotechnology.</p>	
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PRACTICALS: RPSLScP.E516 (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 50 marks.
- The pattern of the practical paper is as follows:

Semester	Papers	Question	Total marks
III	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	RPSLSc.E515	Proposal writing, presentation with review article	10
		Project table work	50
		Thesis submission	20
		Final presentation & viva	20
Total marks			100

Ramnarain Ruia Autonomous College

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 (100 marks) FP	Presentation	30	
	Report	50	
	Viva	20	
VI (100 marks) DSE	Theory	45	
	Internal	30	
	Practical	25	

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

SEMESTER III

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	L / WEEK
Paper I	Fermentation Technology and Tissue culture			
RPSLSc301	I	Upstream and Downstream Processes	4	4
	II	Fermentation processes and Enzymes in Industry		4
	III	Plant Tissue Culture and Transgenic Plants		4
	IV	Animal Tissue Culture		4
Paper II	Applied Biotechnology			
RPSLSc302	I	Assisted reproductive technology	4	4
	II	Nanotechnology		4
	III	New emergent Technology		4
	IV	Diagnostics and Forensics		4
Paper III	Bioinformatics, International Standards and Bioethics			
RPSLSc303	I	Introduction to Bioinformatics	4	4
	II	Alignment problem and solutions		4
	III	ISO, GMP & GLP		4
	IV	Bioethics and Entrepreneurship		4
Paper IV RPSLSc304	Internship / Project Work			8



Ramnarain Ruia Autonomous College

SEMESTER III

PAPER I

Course Code: RPSLSc301

Course Title: Fermentation Technology and its Applications

COURSE OUTCOMES: This paper is dedicated to the industrial aspects & applications where students acquire knowledge about the various fermentation processes and concepts behind them.

COURSE OUTCOME	DESCRIPTION At the end of the course students will be able to:
CO 1	Understand the fundamental concepts of fermentation techniques, methods used for product recovery, the associated product economics 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.
CO 3	Derive microbial growth kinetics for fermentation processes and optimize the culture conditions to scale up the production.
CO 4	Identify and analyse techniques of isolation, preservation of microbial cultures and various fermentation media used for optimum production.
CO 5	Classify plant secondary metabolites and understand the industrial production of some important metabolites.
CO 6	Enlist the scope of enzymes in various commercial industrial productions of food, nutraceuticals, and other essentials.

DETAILED SYLLABUS - Paper I

Course Code: RPSLSc301

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><u>Unit I: Upstream and Downstream Processes</u></p> <p>Fermenter design: Components of the fermenter, sterilization, aeration, and agitation.</p> <p>Types of Fermenters: batch, continuous, air lift, fluidized bed, stirred tank.</p> <p>Isolation and Screening of microorganisms: Isolation of microorganisms from various sources, Preservation, Primary and Secondary Screening of microorganisms.</p> <p>Fermentation Media: Definition, Criteria, Various components, Types: crude and synthetic, sterilization, rheology of various components of media.</p> <p>Microbial growth: General parameters, growth kinetics for various fermentation and types of stock culture, scaling up of culture for fermentation.</p> <p>Product recovery: Product: internal, external, cell disruption methods: physical, chemical, and biological, precipitation, filtration, centrifugation, extraction, and purification, drying.</p> <p>Product Economics: Microbial culture, Fermentation: Upstream and Downstream processes, recovery process, product processing.</p> <p>Effluent Treatment: Need, Traditional methods disposal and disadvantage, physical, chemical, and biological methods.</p>	1/ 15L
II	<p><u>Unit II: Fermentation processes and Enzymes in Industry</u></p> <p>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.</p> <p>Commercial Fermentations:</p> <p>Cheese: Culture, Fermentation process, Applications.</p> <p>Alcohol: Wine, Commercial Ethanol (by-product fusel oils): Culture, Process and Applications.</p> <p>Acids: Lactic acid industrial production and applications.</p> <p>Carbohydrate: High fructose corn syrup.</p> <p>Secondary metabolites from microbes: Polymers, antibiotics, biosurfactants.</p> <p>Biotransformations: Classification and characteristics of enzymes – OTHLIL, applications of enzymes: (chiral synthesis of enantiomerically pure compounds, resolution of isomers). Examples of biotransformations.</p> <p>Industries: Textile Processing, Leather Processing, Paper & Pulp Processing, Detergents, and laundry.</p> <p>Food biotechnology: Fruit and vegetable processing: juices, nectars, purees; syrup and glucose isomerases, enzymatic synthesis of aspartame.</p> <p>Other industrial uses: Vinegar, Baking, Cocoa fermentation, Olive oil production,</p>	1/ 15L

	<p>fish processing industries.</p> <p>Nutraceuticals: Probiotics: lycopene, isoflavonoids, glucosamine, phytosterol.</p> <p>Feed Biotechnology: lignocelluloses into feed using cellulases, silage.</p> <p>Bio preservation: chemical preservatives and their safety concerns, LAB Bacteriocins. Types of bacteriocins, mode of action, applications, and regulations.</p>	
III	<p><u>Unit III - Plant Tissue Culture and Transgenic Plants</u></p> <p>Basics of plant tissue culture: Laboratory set up and requirements, totipotency, macro and micro nutrients, media components and types.</p> <p>Micropropagation: Steps involved, Culturing woody plants, Advantages, Somaclonal variation</p> <p>Culture: Somatic embryogenesis and synthetic seed production. Callus culture and growth curves, Suspension cell culture. Protoplast culture, Somatic hybridization, Cybrids.</p> <p>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]</p> <p>Contamination: Explant source, contamination types, disinfecting agents, control of microbial contaminants.</p> <p>Conservation: Improvement, exploitation and conservation of genetic resources, Cryopreservation of genetic resources.</p> <p>Plant recombinant technology: Plant transformation by <i>Agrobacterium tumefaciens</i>, <i>A. rhizogenes</i> and its plasmid.</p> <p>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.</p> <p>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.</p>	1/ 15L
IV	<p><u>Unit IV: Animal Tissue culture</u></p> <p>Basics of animal tissue culture: Methods of cell dissociation/separation and preparation of primary cell culture, characteristics of cells <i>in vitro</i>, cell culture growth parameters, detection, prevention, and determination of contamination in tissue culture.</p> <p>Culture: Primary cell culture, immortalized cell culture, stem cell culture and transformed cell culture. Specialized cells: bone marrow, skin cell culture, myogenesis, erythropoiesis and chondrogenesis- <i>in vitro</i>,</p> <p>Preservation: Cryopreservation of tissues and cell lines.</p> <p>Analysis and Production: cell synchronization, cell transformation <i>in vitro</i>, Mass</p>	1/ 15L

	cultivation- cytodex and bio fermenters. Applications: Stem cells & therapeutic cloning, Tissue engineering and 3D printing.	
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PRACTICALS: RPSLScP301 (2 credits)

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 cellulase activity using Filter paper assay/ carboxy-methyl cellulose assay.
4. Effect of elicitor(s) on the production of a plant secondary metabolite using plant tissue culture (dye/ drug Alkaloids etc.)
5. Isolation and estimation of Nutraceuticals (lycopene/ isoflavonoids) by TLC.
6. Micropropagation of selected ex-plants.
7. Estimation of tannins using the Vanillin Hydrochloride method.
8. Establishment of a Primary Culture (ATC) using a suitable source.

References:

1. Principles of Fermentation Technology by Stanbury and Whitaker
2. Industrial Microbiology by Casida
3. Industrial Microbiology by Prescott and Dunn
4. Role of Biotechnology in Medicinal and Aromatics Plants by Khan and Khanum Vol.1
5. Plant Tissue Culture by M. K. Razdan.

PAPER II
Course Code: RPSLSc302
Course Title: Applied Biotechnology

COURSE OUTCOMES: Applied biotechnology is a paper which includes a diverse range of fields like assisted reproductive technology, nanotechnology, forensics, microfluidics, biosensor design and biomimetics. This gives students the ability to understand a wide variety of application and career-oriented subjects.

COURSE OUTCOME	DESCRIPTION
	At the end of the course students will be able to:
CO 1	Describe the issues behind infertility, the physiology of reproduction, principles and techniques of ART, cryobiology and latest developments in the field.
CO 2	Classify nanostructures based on their structure and properties and appraise the novel applications of this technology.
CO 3	Synthesize silver, zinc oxide and ferromagnetic nanoparticles in the laboratory and determine their biological activity.
CO 4	Design a microfluidics system by analysing various parameters and its applications.
CO 5	Identify the ways to create an accurate, quick but cost-effective diagnostic kit for a certain disorder or infection.
CO 6	Employ the basics of forensic science to perform simple experiments like hair microscopy and put their investigative and deducing skills to the test.

DETAILED SYLLABUS - Paper III

Course Code: RPSLSc302

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><u>Unit I: Assisted Reproductive Technology</u></p> <p>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.</p> <p>In Vitro Fertilization (IVF): Stimulation protocols for IVF, Baseline assessment, sperm and egg culture, cryopreservation. Risks of IVF.</p> <p>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,</p> <p>Transfer of embryos- Direct embryo transfer, Zygote intrafallopian transfer (ZIFT).</p>	1/ 15L
II	<p><u>Unit II: Nanotechnology</u></p> <p>Nanobiotechnology: Concept. Types of nanostructures (Carbon nanostructures, nanoshells, dendrimers, quantum dots, nanowires, liposomes). Potential risks of Nanobiotechnology.</p> <p>Synthesis of nanoparticles: Physical, chemical and biological methods.</p> <p>Applications of nanotechnology: medicine and diagnostics (antimicrobial properties, therapies, drug delivery including rate programmed drug delivery, Microencapsulation of cells. imaging) agriculture, environment.</p>	1/ 15L
III	<p><u>Unit III: New emergent Technology</u></p> <p>Biosensors: Concepts. Types of biosensors: amperometric, potentiometric, conductometric, calorimetric, peizoelectric, evanescent wave sensors, Surface Plasmon resonance, whole cell biosensors.</p> <p>Biomimetics: Concept and applications: Dry Adhesion (gecko lizard's foot), Water repulsion (lotus leaf), nanostructures in colour display (butterfly wings/ peacock feather).</p> <p>Microfluidics: Fundamental characteristics of fluidics at microscales applications of microfluidics (cell separation, dip sticks).</p> <p>Biomechanics: Introduction and Biotechnology in biomechanics.</p>	1/ 15L

IV	<p><u>Unit IV: Diagnostics and Forensics</u></p> <p>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;</p> <p>Forensics: 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.</p>	1/ 15L
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PRACTICALS: RPSLScP302 (2 credits)

1. Synthesis of silver/ zinc oxide nanoparticles - biological method.
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. Antioxidant activity of silver/zinc oxide nanoparticles.
5. Demonstration of Laminar Flow in Microfluidic system
6. Hair microscopy / fingerprint lifting for forensic analysis.
7. PAGE of DNA samples and silver staining.
8. Construction of a lateral-flow diagnostic strip.

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 III

Course Code: RPSLSc303

Course Title: Bioinformatics, International Standards and Bioethics.

COURSE OUTCOMES: In this paper students will be introduced to the theoretical and practical techniques of bioinformatics. The application of bioinformatics and biological databases to problem solving real research problems will be emphasised on. This paper also includes a brief introduction to international standards, bio-entrepreneurship as well as various bioethical issues.

COURSE OUTCOME	DESCRIPTION At the end of the course students will be able to:
CO 1	Classify the biological databases that are used in bioinformatics and select and use the appropriate biological database according to the query.
CO 2	Construct phylogenetic trees manually as well as computationally after understanding the concepts, terminologies, types and properties of phylogenetic trees and the various methods of building it.
CO 3	Understand the concept of multiple or pairwise sequence alignment and select the appropriate software to carry out the alignment.
CO 4	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 5	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 6	Debate on diverse topics involving bioethics and understand the relevance of bioethics in regulating exciting developments in biology and medicine.

DETAILED SYLLABUS - Paper II

Course Code: RPSLSc303

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><u>Unit I: Introduction to Bioinformatics</u></p> <p>Definition and History of Bioinformatics, Different Omics and its application and Current status.</p> <p>Computers: Operating systems, Internet and its components, Internet sources for Bioinformatics, Flat file.</p> <p>Biological databases: Classification, Primary DNA Databases, Primary and Secondary Protein Databases, Composite Structure Databases, UniProt, Protein Data Bank (PDB), Metabolism Database (KEGG).</p> <p>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).</p> <p>Techniques: Sanger sequence analysis, Primer design, Restriction mapping.</p>	1/ 15L
II	<p><u>Unit II: Alignment problem and solutions</u></p> <p>Multiple Sequence Alignment (MSA): Definition, Objective, Consensus, Methods for MSA: Heuristic approach, Dynamic programming approach and their combinations.</p> <p>Pairwise Alignment: Introduction, PAM Matrix, BLOSUM Matrix, The Dot Plot, Global alignment, Local alignment, FASTA and BLAST. Statistics: P and E value.</p> <p>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.</p>	1/ 15L
III	<p><u>Unit III: ISO, GMP, GLP</u></p> <p>Introduction: Overview of standards in ISO9000 Family</p> <p>Key principles: Key principles of ISO 9000- Quality Management System</p> <p>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</p> <p>Application: Sector specific Application of ISO 9001- Quality Management System adapted by various industries</p>	1/ 15L

	<p>Introduction to GMP (Good Manufacturing Practices) and GLP (good Laboratory Practices) in Pharmaceutical Industries.</p> <p>Overview: GMPs and enforcement by the U.S. Food Drug Administration (US FDA) under Title 21 CFR. Documentation requirement related to GMP and GLP.</p> <p>Case studies for SOP preparation and CAPA (Corrective action Preventive Action).</p>	
IV	<p><u>Unit IV: Bioethics and Entrepreneurship</u></p> <p>Bioethics: Definition – moral, values, ethics and ethics in biology; Role and importance of ethics in biology; Legal and regulatory issues; Bioethics in healthcare, agriculture, modern biology, biotechnology, animal welfare & right / animals in research, wildlife conservation and management, commercialism in scientific research.</p> <p>Entrepreneurship:</p> <p>Biotechnology industry - Emerging trends in biotechnology industry, organizational structure.</p> <p>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.</p> <p>Licensing - Motivations for licencing, scope, types and fees.</p> <p>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.</p> <p>Bioentrepreneurs – Bio-entrepreneurship in Rural and Urban India, examples of Indian Bioentrepreneurs.</p>	1/ 15L

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
5. Economics of Biotechnology by T.V.S Rama Mohan Rao
6. Entrepreneurship and Business of Biotechnology by S. N. Jogdand
7. Economic dynamics of Modern Biotechnology by Maureen D. McKelvey, Annika Rickne, Jens Laage-Hellman
8. ISO 9000 quality systems handbook fourth edition by David Hoyle
9. International standard ISO 9001: quality management systems requirements 5th edition 2015-09-15.
10. Jürg P. Seiler - Good Laboratory Practice - the Why and the How (2005, Springer)
11. Good Manufacturing Practices and Inspection -Volume 2 (2007, World Health Organization)
12. GLP Essentials - A Concise Guide to Good Laboratory Practice by Milton A. Anderson - (2002, CRC Press).

PAPER V
Course Code: RPSLSc304
Course Title: Internship/Project work (8 credits)

COURSE OUTCOMES: This paper is meant entirely for an individual research project which can be carried out in research institutes like ACTREC, NIRRH, BARC, etc. or in the college itself which will culminate in a final presentation, *viva voce* and thesis.

COURSE OUTCOME	DESCRIPTION At the end of the course students will be able to:
CO 1	Follow and develop the 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	Gain experience and form networks with professionals in the institute/industry of their choice.

Assessment Modalities

Theory Examination Pattern:

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

A) Internal Assessment: 40 Marks

- Assignments include presentation on any research paper / conference/ guest lecture / design of website or brochure / quizzes / subjective tests / preparation of business plan/ creative writing / mock audit / 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- 60 Marks

Duration - The examinations shall be of **2 ½ hrs duration**. Theory question paper pattern is for 60 marks with 60% choice as shown below.

Semester	Papers	Units covered	Question numbers and choice	Marks for each question	Total marks
III	1, 2, 3	1	Q1 - A, B, C (any two out of three)	06	12
		2	Q2 - A, B, C (any two out of three)	06	12
		3	Q3 - A, B, C (any two out of three)	06	12
		4	Q4 - A, B, C (any two out of three)	06	12
		1 question each from all 4 units	Q5 - i, ii, iii, iv (any three out of four)	04	12
Total marks					60

Practical Examination Pattern: 50 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 and 2	Q1. Major experiment	30
		Q2. Identification	10
		Q3. <i>Viva voce</i>	5
		Q4. Journal	5
Total marks			50

Paper IV Examination Pattern: 200 Marks

Semester	Paper	Question	Total marks
III	4	Q1. Project work thesis	50
		Q2. Project work presentation	50
		Q3. <i>Viva voce</i> on project	100
Total marks			200

Overall Examination & Marks Distribution Pattern**Semester III**

PAPER	EXAM	MARKS	GRAND TOTAL
I (150 marks)	Theory	60	600 marks
	Internals	40	
	Practical	50	
II (150 marks)	Theory	60	
	Internals	40	
	Practical	50	
III (100 marks)	Theory	60	
	Internals	40	
IV (200 marks)	Internship report / Project thesis and presentation	100	
	Internship / Project viva	100	

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

SEMESTER IV

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	L / WEEK
Paper I	Medical Biotechnology			
RPSLSc401	I	Therapeutics I	4	4
	II	Therapeutics II		4
	III	Activity Guided Drug Development		4
	IV	Pharmacogenomics and Drug design		4
Paper II	Environmental Biotechnology			
RPSLSc402	I	Biological Controls and Biopesticides	4	4
	II	Nitrogen Fixation and Biofertilizers		4
	III	Bioremediation		4
	IV	Phytoremediation and phytomining		4
Paper III	Protein studies and Biomathematics			
RPSLSc403	I	Protein Trafficking and Targeting	4	4
	II	Protein folding and Biomolecular interactions		4
	III	Proteomics		4
	IV	Biomathematics		4
Paper IV RPSLSc404	Project Work		6	

SEMESTER IV

PAPER I

Course Code: RPSLSc401

Course Title: Medical Biotechnology

COURSE OUTCOMES: Students gain insightful knowledge regarding the applications of biotechnology in the field of medicine.

COURSE OUTCOME	DESCRIPTION At the end of the course students will be able to:
CO 1	Understand the principles, classification, production and examples of gene therapy, antisense therapy, and protein therapeutics.
CO 2	Distinguish between gene therapy, antisense therapy and protein therapeutics and select the appropriate therapy for the treatment of a certain disease.
CO 3	Recall the important new 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	Assess the pharmacogenomics of various illnesses like cancer syndromes, neuropsychotic and cardiovascular disorders.
CO 6	Investigate the steps involved in drug designing right from identification of the API in activity guided drug development to its metabolism and action.

DETAILED SYLLABUS - Paper I

Course Code: RPSLSc401

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><u>Unit I: Therapeutics I</u></p> <p>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.</p> <p>Antisense therapy: Introduction, strategies. oligodeoxyribonucleotide, catalytic antisense RNA, triple - helix forming oligonucleotides (TFOs), production, and limitations, first generation antisense drugs, second generation antisense drugs. Applications: cancer therapy, viral diseases, gene function analysis and in agriculture.</p> <p>Gene therapy: Overview, Vectors for somatic cell gene therapy, Gene therapy for inherited immunodeficiency syndromes, Cancer gene therapy, Cystic fibrosis gene therapy, HIV-1 gene therapy. Safety issues.</p>	1/ 15L
II	<p><u>Unit II: Therapeutics II</u></p> <p>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 - <i>Pseudorabies Virus</i>, <i>Vibrio</i> and <i>Poliovirus</i>, Recombinant Live Vectors - <i>Vaccinia Virus</i>, Recombinant BCG Vaccines, Attenuated <i>Salmonella</i> Strains, Poliovirus Chimaeras, Cross-species Vaccination, ‘Live- dead’ Vaccines, Other Virus Vectors and Recombinant <i>E. coli</i> 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.</p> <p>Peptibodies: Definition, peptide-Fc fusion, advantages over monoclonal antibodies, production in <i>E. coli</i> using recombinant DNA technology, production, and mechanism of action, applications – pain, ovarian cancer and immune thrombocytopenic purpura, limitations.</p> <p>Peptidomimetics: Definition, design, features, analysis, and application.</p>	1/ 15L

	Biosimilars: Definition, design, features, analysis, and application.	
III	<p><u>Unit III: Activity Guided Drug Development</u></p> <p>Plant collection and Extract preparations: Methods of Plant collection, solvent extraction (cold, hot, critical fluid extraction etc), screening of medicinal properties;</p> <p>Natural products: methods of identification (Qualitative and Quantitative), isolation and purification (Chromatography), Characterization;</p> <p>Bio efficacy studies: <i>In vitro</i> testing- Antimicrobial, Antidiabetic, Antioxidant, Anti Inflammatory and Anti larvicidal activities.</p> <p>Drug Development: Introduction to the pharmaceutical industry, Natural drugs versus Synthetic drugs, Timeline of drug discovery, pharmacodynamics, plasma 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.</p>	1/ 15L
IV	<p><u>Unit IV: Pharmacogenomics and Drug design</u></p> <p>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.</p> <p>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.</p>	1/ 15L

PRACTICALS: RPSLScP401 (2 credits)

1. Residual DNA analysis of recombinant therapeutic protein.
2. Multiplex PCR.
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.
7. *In silico* ADME analysis using SWISS ADME.
8. Anti-larvicidal 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).

Ramnarain Ruia Autonomous College

PAPER II
Course Code: RPSLSc402
Course Title: Environmental Biotechnology

COURSE OUTCOMES: Environmental biotechnology is a vital branch of biotechnology which deals with the use of the principles of biotechnology to improve the environment for humans as well as other organisms.

COURSE OUTCOME	DESCRIPTION
	At the end of the course students will be able to:
CO 1	Investigate the challenges of pests to agriculture and the biological alternatives to harmful chemical pesticides.
CO 2	Evaluate the importance of Integrated Pest Management to sustain the least amount of crop damage while maintaining pest populations.
CO 3	Compare the use of chemical fertilizers with biological alternatives and the use of genetic engineering to improve nitrogen fixation.
CO 4	Understand soil enriching techniques like composting, the ecological role of mycorrhiza, the emerging technique of aquaponics as well as the lucrative technique of phytomining of precious metals like gold.
CO 5	Examine the issue of Solid Waste Management, associated laws and regulations, status of the steps taken by the government like the ‘Swachh Bharat Abhiyaan’
CO 6	Describe the concept of remediation studying plants or microbes, explain various adaptive mechanisms for pollutant tolerance and applications for environmental protection.

DETAILED SYLLABUS - Paper II

Course Code: RPSLSc402

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><u>Unit I: Biological Controls and Biopesticides</u></p> <p>Chemical Pesticides: Spectrum of chemical pesticides for control of biotic stress: uses, advantages and disadvantages.</p> <p>Spectrum of biological pesticides: types, advantage on chemical pesticides, mode of action, stability and formulation in natural and genetically modified organisms, Selective targeting, Molecular mechanism of resistance development and strategies including integrated pest management.</p> <p>Biopesticides from Plants: Neem and pyrethrin, mode of action on insect pests, Bio-control against fungal diseases of plants.</p> <p>Biological Controls: Viral/ fungal/ bacterial parasites for control of insect pests, life cycle, symptoms, and mode of action.</p>	1/ 15L
II	<p><u>Unit II: Nitrogen Fixation and Biofertilizers</u></p> <p>Nitrogen fixation: Molecular genetics: <i>nif</i> genes and regulation of <i>nif</i> gene expression, <i>fix</i> genes.</p> <p>Biofertilizer: definition, methods of manufacture, application to soil and seed.</p> <p>Aquaponics: fish culture and plant culture using this water.</p> <p>Mycorrhiza: Types, importance to plant health (nutrient uptake, resistance to stress, microbial symbiosis), importance of network analysis, role in ecosystem (Plant to plant interaction).</p> <p>Biofuels: Liquid and gaseous. Bioenergy: Biofuels - Introduction, in the form of gas–hydrogen and methane (biogas), biofuel in form of liquid– ethanol and diesel, biofuel from phytoplankton.</p>	1/ 15L
III	<p><u>Unit III: Bioremediation</u></p> <p>Solid waste management: Types of waste, need of waste management, proximate and ultimate analyses of solid wastes, transportation, laws, and regulations. Swachh Bharat Mission-Urban, Treatment methods.</p> <p>Composting: physical and chemical factors, microbiology, health risk from pathogens, odour sources.</p> <p>Adaptation: Effect of metals and salts on the growth of microbes and higher organisms. Different adaptation mechanism to tolerate higher concentration of metals by organisms.</p> <p>Bioremediation: using natural, genetically engineered bacterial systems and plants</p>	1/ 15L

	with examples.	
IV	<p>Unit IV: Phytoremediation and phytomining</p> <p>Phytoremediation: Contaminants treated, Contaminant removal mechanisms of plants, Site conditions, Procedure, Types of phytoremediation, Criteria for good phytoextractors. Improvement of phytoremediation using genetic engineering. Advantages and disadvantages of phytoremediation. Aquatic plants used for wastewater treatment. Indicator plants, Restoration of soil, water and air quality citing suitable examples.</p> <p>Phytomining: Factors influencing metal uptake by plants in soil, Implementing phytomining, extraction of valuable minerals/ metals from low grade ore/soils.</p> <p>Biotechnology in gold mining/ extraction.</p>	1/ 15L

PRACTICALS: RPSLScP402 (2 credits)

1. Soil analysis - chloride, organic matter, & calcium carbonate content.
2. Waste water analysis - pH, Total solids, BOD, Hardness, acidity, alkalinity, and chlorides.
3. Effect of Neem pesticides on plant pathogens.
4. Staining of mycorrhiza from root tips.
5. Analysis of metals accumulation in plants.
6. Identification of indicator plants for environmental conditions
7. Biofuels production from algae.
8. Isolation and selection of oil-degrading bacteria for bioremediation.

References:

1. Environmental Biotechnology by M. H. Fulekar
2. Environmental Sciences: Odum
3. Environmental Biotechnology: Alan Scragg
4. Environmental Biotechnology: Bimal Bhattachraya and Ritu Banerjee
5. Environmental pollution control engineering. C. S. Rao. New Age International Publishers.

PAPER IV
Course Code: RPSLSc403
Course Title: Protein Studies and Biomathematics

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
	At the end of the course students will be able to:
CO 1	Acquire in-depth knowledge of the types, mechanisms, quality control systems of protein trafficking and targeting machinery to various cellular compartments.
CO 2	Understand 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	Recognize the ability of all the biomolecules to interact with each other to carry out all the metabolic processes.
CO 4	Understand the concepts and advanced tools used in the field of proteomics to give an overall perspective of complete protein studies under one roof.
CO 5	Visualize drug docking sites of target proteins in the process of drug discovery.
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.

DETAILED SYLLABUS - Paper III

Course Code: RPSLSc403

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><u>Unit I: Protein Trafficking and Targeting</u></p> <p>Intracellular and membrane protein trafficking and targeting; Secretory pathways in prokaryotes and eukaryotes;</p> <p>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.</p> <p>Quality control - UPR, ERAD and proteosomal degradation. Post-translational transport - Targeting of mitochondrial, chloroplast, peroxisomal and nuclear proteins;</p> <p>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.</p>	1/ 15L
II	<p><u>Unit II: Protein folding and Biomolecular interactions</u></p> <p>Thermodynamics: The laws of thermodynamics, enthalpy, entropy and free energy concepts and their relevance to biological systems.</p> <p>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.</p> <p>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.</p>	1/ 15L

III	<p><u>Unit III: Proteomics</u></p> <p>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 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.</p> <p>Application in drug designing: Drug targets, Lead Identification and Modification, Computer-Aided Drug Design.</p>	1/ 15L
IV	<p><u>Unit IV: Biomathematics</u></p> <p>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)</p> <p>Differential equations --homogeneous and Linear ODE's and its simple applications to biological problems. Applications of maths in biology.</p>	1/ 15L

PRACTICALS for RPSLScP403 (2 credits)

1. Isolation and partial purification of Acid/ Alkaline phosphatase from potato.
2. Analysis of purification fold of the extracted enzyme.
3. Determination of molecular weight of enzyme by SDS-PAGE.
4. *In silico* molecular docking using PyRx and Discovery Studio.
5. Analysis of a protein binding site using the CASTp server.
6. Secondary Structure Prediction: Porter 5.0
7. Homology modelling using SWISS-MODEL.
8. Protein-protein interaction network analysis using STRING.

References:

1. Molecular cell biology by Lodish (5th Edition).
2. Biochemistry by Stryer.
3. Biochemistry by Harper.
4. Introduction to Bioinformatics- Attwood, Parry-Smith and Phukan.
5. Fundamentals of Bioinformatics: Harisha S.
6. Bioinformatics and Molecular Evolution: Higgs & Attwood.
7. Bioinformatics: Harshwardhan Pal.

PAPER IV

Course Code: RPSLSC404

Course Title: Project Work (6 credits)

COURSE OUTCOMES: This paper is meant entirely for an individual research project which can be carried out in the department which will culminate in a final presentation, *viva voce* and thesis.

COURSE OUTCOME	DESCRIPTION At the end of the course students will be able to:
CO 1	Follow and develop the 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	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.

Assessment Modalities

Theory Examination Pattern:

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

A) Internal Assessment: 40 Marks

- Assignments include presentation on any research paper / conference/ guest lecture / design of website or brochure / quizzes / subjective tests / preparation of business plan/ creative writing / mock audit / 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- 60 Marks

Duration - The examinations shall be of **2 ½ hrs duration**. Theory question paper pattern is for 60 marks with 60% choice as shown below.

Semester	Papers	Units covered	Question numbers and choice	Marks for each question	Total marks
IV	I, II, III	1	Q1 - A, B, C (any two out of three)	06	12
		2	Q2 - A, B, C (any two out of three)	06	12
		3	Q3 - A, B, C (any two out of three)	06	12
		4	Q4 - A, B, C (any two out of three)	06	12
		1 question each from all 4 units	Q5 - i, ii, iii, iv (any three out of four)	04	12
Total marks					60

Practical Examination Pattern: 50 Marks

- Assessment of practical exam 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
IV	1, 2, 3	Q1. Major experiment	30
		Q2. Identification	10
		Q3. <i>Viva voce</i>	5
		Q4. Journal	5
Total marks			50

Paper IV Practical Examination Pattern: 150 Marks

Semester	Paper	Question	Total marks
IV	4	Q1. Project work thesis	60
		Q2. Project work presentation	40
		Q3. <i>Viva voce</i> on project	50
Total marks			150

Overall Examination & Marks Distribution Pattern

Semester IV

PAPER	EXAM	MARKS	GRAND TOTAL
I (150 marks)	Theory	60	600 marks
	Internals	40	
	Practicals	50	
II (150 marks)	Theory	60	
	Internals	40	
	Practicals	50	
III (150 marks)	Theory	60	
	Internals	40	
	Practicals	50	
IV (150 marks)	Project Dissertation & Presentation	100	
	Project Viva	50	
