

Resolution number: AB/II (20-21).2.RPS8

S. P. Mandali's
Ramnarin Ruia Autonomous College
(Affiliated to University of Mumbai)



Syllabus for Masters of Science

Program: M.Sc. Life Science

Program Code: RPSLSc

(Credit Based Semester and Grading System for
academic year 2020–2021)

Program outcomes 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.

PO	PO Description
	A student completing Master's Degree in Science program will be able to:
PO 1	Demonstrate in depth understanding in the relevant science discipline. Recall, explain, extrapolate and organize conceptual scientific knowledge for execution and application and also to evaluate its relevance.
PO 2	Critically evaluate, analyze and comprehend a scientific problem. Think creatively, experiment and generate a solution independently, check and validate it and modify if necessary.
PO 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.
PO 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.
PO 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 different groups.
PO 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.
PO 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.
PO 8	Understand cross disciplinary relevance of scientific developments and relearn and reskill so as to adapt to technological advancements.

PROGRAM SPECIFIC OUTCOMES

Program: M.Sc. Life Science

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

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 CSIR NET (Council of Scientific & Industrial Research – National Eligibility Test) exam 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 subjects.

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 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 dissertation projects. The second semester is a mix of basic subjects such as Animal and Plant Physiology, Microbiology, Immunology as well as advanced subjects like Cellular signaling, 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. Topics like Tissue culture, Fermentation technology and Bioinformatics are focused on which have a direct industrial application. Students will also get a chance to work on an individual research project either in research institutes like ACTREC, NIRRH, BARC, etc. or in the college itself. The individual project work will culminate in a final presentation and thesis at the end of the third semester. Students can also publish their work if suitable.

The final semester rounds off the knowledge they have gained by focusing on promising areas of research like Microfluidics and Nanobiotechnology. Environmental biotechnology and novel areas of research involved in it are also taught to allow the students to find possibilities in improving the environment. The students will also be exposed to the fundamentals of the Pharmaceutical and Medical biotechnology industries.

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 endeavors.

PROGRAM OUTLINE

YEAR	SEM	COURSE CODE	COURSE TITLE	CREDITS
2020-21	I	RPSLSC101	Environmental Biology, Biodiversity and Evolution	6
	I	RPSLSC102	Cell and Molecular Biology	6
	I	RPSLSC103	Biochemical Studies	6
	I	RPSLSC104	Research basics and IPR	6
	II	RPSLSC201	Microbiology, Immunology and Plant Physiology	6
	II	RPSLSC202	Model organisms and life processes	6
	II	RPSLSC203	Genetic manipulation and Cell signalling	6
	II	RPSLSC204	Genetic Engineering	6
2021-22	III	RPSLSC301	Tissue culture and Aquaculture	6
	III	RPSLSC302	Fermentation Technology and its Applications	6
	III	RPSLSC303	Bioinformatics, International Standards & Bioethics	6
	III	RPSLSC304	Project Work	6
	IV	RPSLSC401	Medical Biotechnology	6
	IV	RPSLSC402	Applied Biotechnology	6
	IV	RPSLSC403	Environmental Biotechnology	6
	IV	RPSLSC404	Protein studies, Advanced Bioinformatics and Biomathematics	6

M.Sc. Part - I Life Sciences Syllabus

SEMESTER I

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	L / WEEK
Paper I	Environmental Biology, Biodiversity and Evolution			
RPSLSc101	I	Environmental biology	4	4
	II	Biodiversity Management and GMOs		4
	III	Evolution		4
	IV	Use of software in research		4
Paper II	Cell and Molecular Biology			
RPSLSc102	I	Cell Biology	4	4
	II	Genetics		4
	III	DNA Replication, Repair & Recombination		4
	IV	Transcription and Translation		4
Paper III	Biochemical studies			
RPSLSc103	I	Proteins and Lipids	4	4
	II	Carbohydrates, vitamins and minerals		4
	III	Enzymology		4
	IV	Photosynthesis and Mitochondrial and Chloroplast Electron Transport Chain		4
Paper IV	Research Basics and IPR			
RPSLSc104	I	Research Methodology and Scientific writing	4	4
	II	Biostatistics		4
	III	Instrumentation		4
	IV	IPR		4

SEMESTER I

PAPER I

Course Code: RPSLSc101

Course Title: Environmental Biology, Biodiversity and Evolution

COURSE OUTCOMES:

This paper covers the basics in ecology, environmental science, biodiversity, evolution, paleontology and astrobiology. It also covers the use of software applications that are essential in research.

COURSE OUTCOME	DESCRIPTION At the end of the course students will be able to:
CO 1	Gain an understanding of ecological concepts and environmental issues.
CO 2	Apply the concepts to their day to day life in order to benefit the environment.
CO 3	Understand the value of biodiversity and the importance of conservation.
CO 4	Identify the major events and dates that provide the structure for geologic time on Earth.
CO 5	Understand biological theories and concepts in evolution which forms the basis of phenomena like antibiotic resistance as well as cancer progression.
CO 6	Classify and analyze the type of preservation a fossil has undergone.
CO 7	Appreciate the possibilities of biological lifeforms evolving in outer space.
CO 8	Gain the skills to use various essential software that will help them in their respective careers.
CO 9	Build a fully functional website of their choice.

DETAILED SYLLABUS - Paper I

Course Code/ Unit : RPSLSc101

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><u>Unit I: Environmental biology</u> Ecosystems: Types of ecosystems [terrestrial (Tropical evergreen forests, Tropical deciduous forests, Deserts, Chaparral, Temperate grasslands, Savannahs and thorn forests, Temperate deciduous forests, Boreal forests/ Taiga, Tundra) and aquatic (Lentic, Lotic, Oceans, Estuaries, Coral reefs)], Habitat fragmentation and niche overlap, Competitive exclusion principle, resource partitioning, character displacement and resource management and conservation. Community ecology: Nature of communities; fundamental properties of biological communities (Productivity, Diversity, Complexity, Resilience, Stability, Structure); levels of species diversity and its measurement – Simpson’s diversity index, Shannon index; edges and ecotones, Succession, disturbances and invasion. Population ecology: Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation, demes and dispersal. Environmental health: Environmental stress and adaptation, effects of pollution on living systems, environmental pollutants related human disorders, biomonitoring indicators, Climate change Toxicology: Basic principles of toxicology including LD50 and ED50, management of acute intoxication, Biochemical and Genetic mechanism of natural detoxification.</p>	1/ 16L
II	<p><u>Unit II: Biodiversity Management and GMOs</u> Biodiversity: Concept, characterization, generation, maintenance and loss, Magnitude and distribution of biodiversity, economic value, bioprospecting, ecotourism and biodiversity management approaches. Biodiversity of India. Species interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis. Conservation biology: Principles of conservation, major approaches to management, conservation strategies and cryopreservation. Genetically modified organisms (GMOs): Definition of GMOs, applications in food and agriculture, Release of GMO in environment – risk analysis, risk assessment and risk management, Identification of GMO in environment and their impact, emergence of drugs/ pesticide/ herbicide resistance and disease burden. GMO and GMO product detection and analysis: Detection and analysis of GMOs and GMO products: modified gene copy number determination, detection of chromosomal changes, toxicological studies, residual DNA analysis, product analysis – microbial, biochemical and molecular, toxicological evaluation.</p>	1/ 16L

III	<p><u>Unit III: Evolution</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>Paleontology 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/ 16L
IV	<p><u>Unit IV: Use of Software in Research</u></p> <p>Literature Search: Query formulation, PubMed, NCBI, Google Scholar, Shodganga, etc. Paywalls and smart search engines.</p> <p>Word Processing systems, Microsoft Word, LATEX.</p> <p>Image Editors: Guidelines for publishing images, Adobe Photoshop, Image J.</p> <p>Referencing: Mendeley, Google Docs, EndNote, Zotero.</p> <p>Graphing & Statistics: Microsoft Excel, Google Sheets, GraphPad Prism, MaxStat, IBM SPSS.</p> <p>Anti Plagiarism: Grammarly, Plagiarism checker X, TurnItIn, Online plagiarism checkers.</p> <p>Presentation and Design: Microsoft PowerPoint, Google Slides, Microsoft Publisher.</p> <p>Website building – Wix website design and publishing.</p> <p>Miscellaneous: Using Cloud tools, Microsoft OneNote, Lightshot, Google lens.</p>	1/ 16L

PRACTICALS: RPSLScP101 (2 credits)

1. Study of animal interactions (For identification):
2. Determination of population density (*Daphnia* or any suitable organism) by sub sampling method.
3. Determine the Simpson's diversity index/ Shannon index of a given population.
4. Effect of toxicity on *Daphnia* / *C. elegans* / *Yeast* / *Pollen grains*. Biostatistical analysis using statistics software.
5. Production/ Extraction of biofuel from plant source and characterization.
7. Practical on fossil specimen (ID)
9. Determination of phosphorus by the Fiske-Subbarao method.
10. Honey analysis.

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 Calveret *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.
- David Wright and Pamela Welbourn, Environmental Toxicology, Cambridge university press

PAPER II
Course Code: RPSLSc102
Course Title: Cell and 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 the most basic in-depth fundamentals of cellular structure, components and their functions.
CO 2	Recall the detailed events of one of the highly coordinated processes of the cell cycle, its role, regulation and checkpoints.
CO 3	Explain the importance of cell cycle in growth and development of an organism.
CO 4	Articulate the detailed mechanism involved in DNA replication, recombination and repair.
CO 5	Appreciate the concepts of the central dogma of life from DNA to RNA to proteins which serve the whole purpose of molecular biology.
CO 6	Explain the principles of the inheritance pattern of genes.
CO 7	Understand the comparative aspects of genes right from knowing the microbial genetics to quantitative genetics to population genetics and also the gene mapping methods.

DETAILED SYLLABUS - Paper II

Course Code : RPSLSc102

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><u>Unit I: Cell Biology</u> Plasma membrane: Different model membrane and their structures, lipid bilayer. Endoplasmic reticulum: Structure and function of Rough and smooth ER. Golgi complex: Structure and function, Cisternal progression theories. Nucleus: Structure of nuclear pore complex, lamin proteins, chromatin. Other organelles: Lysosomes, peroxisomes, mitochondria, chloroplasts and vacuoles. Cytoskeleton: Filaments and concept of cellular architecture and motility. Introduction to cell cycle: Stages of the cell cycle – G₀, G₁, S, G₂ and M. Molecular events in the various cell cycle stages. Concept of cyclin and CDKs; activation of the cyclin-CDK complexes. G₁ cyclins: Cln1, Cln2 and Cln3 and its relevance in commitment to cell division. S phase and G₂ phase: S phase cyclin, its inhibitors and pre-replication complex and its significance in DNA replication in the cell cycle. M phase: Prophase, Metaphase, Anaphase and Telophase, condensins, securin, separase and the end of mitosis. Checkpoints (unreplicated DNA, spindle attachment, segregation of chromosomes) Meiosis (special division; Ime2, Rec8 and monopolin) Cell-cell fusion in normal and abnormal cells.</p>	1/ 16L
II	<p><u>Unit II: 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 and Genome wide associated studies, SNPs</p>	1/ 16L

III	<p><u>Unit III: DNA Replication, Repair and Recombination</u></p> <p>DNA replication: Unit of replication and enzymes, replication origin and replication fork, fidelity and processivity of replication, extrachromosomal replicons (plasmid).</p> <p>DNA repair: Direct repair, Excision of base pair, Post replicative, SOS.</p> <p>Recombination: Homologous and Non Homologous.</p>	1/ 16L
IV	<p><u>Unit IV: Transcription and Translation</u></p> <p>Transcription: Classes of RNA molecules - structure and function.</p> <p>Basic features of RNA synthesis: Transcription factors and machinery.</p> <p>Transcription in prokaryotes: E. coli RNA polymerase, transcription activators and repressors, initiation, elongation and termination, processing of tRNA and rRNA in E. coli.</p> <p>Transcription in Eukaryotes - formation of initiation complex, capping, elongation & termination, RNA processing, RNA editing, major and minor splicing systems, polyadenylation, Eukaryotic rRNA genes, formation of eukaryotic tRNA molecules, RNA Polymerases of eukaryotes, RNA polymerase II Promoters, Eukaryotic Promoters for RNA polymerase III, Hypersensitive sites, Upstream activation sites and enhancers.</p> <p>Translation: Outline of Translation.</p> <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>	1/ 16L

PRACTICALS: RPSLScP102 (2 credits)

1. Electron Micrographs of cell organelles and cytoskeletal elements.
2. Localization of cytoskeleton elements using Fluorescence staining.
3. Isolation of chloroplasts and chlorophyll estimation from spinach or any other suitable system.
4. Study of cell stages of mitosis – Onion root tip / meiosis - *Tradescantia*.
5. Inhibition of cell division by colchicine.
6. Isolation and estimation of RNA from Yeast or a suitable system.
7. PCR amplification of 16s rRNA for genus/strain identification.
8. Effect of UV exposure on bacterial colonies to understand DNA repair mechanism.
9. Problems in Genetics:
 - a. Problem solving: Multiple alleles, Lethal genes
 - b. Problem solving: Hardy Weinberg equation, Pedigree analysis.

Reference:

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

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PAPER III
Course Code: RPSLSc103
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	Comprehend 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 which are vital in the development of novel drug/ DNA delivery systems like liposomes.
CO 4	Recall the classification, structural properties of carbohydrates along with the concept of stereochemistry and biological roles.
CO 5	Study the structure, and role of vitamins and minerals and explain their importance with respect to nutritional deficiencies.
CO 6	Appreciate how enzyme structure, active site, substrate interactions, kinetics and regulation of their activities helps all the metabolic pathways to run smoothly.
CO 7	Recognize the importance of energy production and study the pathways and mechanisms involved in ATP synthesis in plants and animals.

DETAILED SYLLABUS - Paper III

Course Code: RPSLSc103

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><u>Unit I: Protein and Lipids</u> Protein: Primary structure elucidation, secondary structure structures eg. Keratin, Collagen, tertiary structure and the underlying interactions/ forces, quaternary structure (example: haemoglobin), protein folding, domains and motifs, cytoskeletal and extracellular proteins. Lipids: structure, classification and properties of lipids, lipid assembly, model membranes, formation of liposomes and drug targeting.</p>	1/ 16L
II	<p><u>Unit II: Carbohydrates, Vitamins, Minerals</u> Carbohydrate: Classification and stereochemistry, structure, properties and biological roles of storage and structural polysaccharides such as, starch, glycogen cellulose, pectin, hemicelluloses, chitin, mucopolysaccharides. Structure and role of N and O- linked glycoproteins and proteoglycans. Vitamins: Structure and biological roles of water soluble and lipid soluble vitamins, vitaminosis and deficiency. Minerals: Structure and biological roles of bulk and trace elements.</p>	1/ 16L
III	<p><u>Unit III: Enzymology</u> Enzyme: enzyme and enzyme substrate interactions, enzyme kinetics, chemical modification, and identification of active site amino acids, mechanism of enzyme catalysis with reference to chymotrypsin, lysozymes, metalloenzymes and the role of metals in catalysis with reference to carboxypeptidase. Regulation of enzyme activity: theory of allostery with reference to AT case, Isozymes with reference to LDH: Coenzymes and their roles, types of enzyme inhibitors and activators and their kinetics, ribozymes and abzymes.</p>	1/ 16L
IV	<p><u>Unit IV: Photosynthesis, Mitochondrial & Chloroplast Electron Transport Chain</u> Photosynthesis: Significance of photosynthesis. The structure, chemical composition, function and origin of Chloroplasts. Photosynthesis pigments, Light energetics, Light and dark phase reaction mechanisms, Photorespiration. CO₂ fixation by C₃, C₄ and CAM pathways. ETC: electron transport chain (ETC) and oxidative/photophosphorylation: structure and function of mitochondrial and chloroplast ETC proteins and light harvesting complex, mechanism of oxidative and photophosphorylation, F₀ F₁ ATPase, theories of ATP synthesis.</p>	1/ 16L

PRACTICALS: RPSLScP103 (2 credits)

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. Estimation of protein by Folin Lowry and Biuret methods. Compare sensitivity by using Folin Lowry method, Biuret method and UV absorbance at 280nm.
4. Lipid extraction and estimation by Bligh and Dyer method.
5. Estimation of ascorbic acid from vegetable source by colorimetric method.
6. Estimation of Ca, Fe, Mg etc from samples using Atomic Absorption Spectroscopy.
7. Polyacrylamide Gel Electrophoresis (PAGE)
 - A. Staining techniques for molecular weight determination: Coomassie and Silver staining.
 - B. Activity staining of enzymes
 - C. Determination of effect of acrylamide concentration on the mobility of proteins

References

Name :Principle of Biochemistry

Author :Lehninger, Albert L. (III Ed. 2000 worth pub)

Publisher: CBs publishers and distributors

Name :Biochemistry

Author :Stryer, Lubert

Publisher: W. H. Freeman

Name :Biochemistry and Molecular biology

Author :Elliott, Willam H, Elliott, Daphne C

Publisher: Oxford University Press

Name : Oxford dictionary of biochemistry and molecular biology

Publisher: Oxford University Press

Name : Proteins- Structures and molecular properties

Author : Creighton, T. E

Publisher: Freeman and Co

Name :Biochemistry of cell membranes: a compendium of selected topics

Author :Papa S., ed. Tager, J. M., ed

Publisher: Birkhauser Verlag

Name :Plant Biochemistry

Author :Hans-Walter Heldt, Birgit Piechulla

Publisher: Academic press

PAPER IV
Course Code: RPSLSc104
Course Title: Research Basics and IPR

COURSE OUTCOMES:

Students will have a strong foundation in essential components of research in Life Sciences like Research methodology, Scientific writing, Instrumentation and Biostatistics, as well as an introduction to Intellectual property rights and patenting.

COURSE OUTCOME	DESCRIPTION At the end of the course students will be able to:
CO 1	Appreciate the scientific research process and the ethics involved.
CO 2	Distinguish between the different types of research methods.
CO 3	Communicate scientific ideas in the form of research papers, grant proposals, posters and presentations.
CO 4	Draft formal letters, statement of purpose, cover letters, emails, replies to reviewers.
CO 5	Select and apply the suitable statistical test depending on the type of data, variables and samples.
CO 6	Gain in-depth knowledge on the principles and working of various basic and advanced instruments essential for research.
CO 7	Determine which molecular biology techniques are most suited for carrying out specific research objectives.
CO 8	Get an insight into the patenting process and other intellectual property rights.

DETAILED SYLLABUS - Paper IV

Course Code: RPSLSc104

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><u>Unit I: Research Methodology and Scientific Writing</u></p> <p>Introduction to research methodology: Meaning, Objectives and Motivation in research;</p> <p>Types of research – Descriptive, Analytical, Applied, Fundamental, Quantitative, Qualitative, Conceptual, Empirical and Other Types of Research;</p> <p>Research Approaches; Research Methods vs. Methodology; Research and Scientific Method;</p> <p>Research Process: Steps of research process; Criteria of Good Research; Sampling, Sample size determination, Plan for data collection, Methods of data collection, Plan for data processing and analysis;</p> <p>Scientific misconduct: Plagiarism, Fabrication, Authorship conflicts, Salami and imalas publication.</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>Presentations: Presenting numerical data - Graphical, Tabular, Animations, Slides etc.</p>	1/ 16L
II	<p><u>Unit II: Biostatistics</u></p> <p>Introduction: Scope, application and uses of statistics, arithmetic mean, median, mode, standard deviation.</p> <p>Correlation and regression: for ungrouped data, scatter diagram, calculation and integration of correlation coefficient, linear regression coefficient and equation of the lines of regression, non-linear relationship transformable to linear form ($Y=abX$, $Y=axb$).</p> <p>Probability: Random variable and its distribution, binomial probability distribution, examples and conditions, means and variance, poisson probability distribution, normal distribution, use of normal probability table for finding probabilities.</p> <p>Population Statistics: Population parameters and sample statistics, sampling techniques, simple random sampling, stratified random sampling, systematic sampling, standard error of mean. Estimation, point and interval, confidence interval</p>	1/ 16L

	<p>for population, mean and proportion.</p> <p>Hypothesis testing: type-1 and type-2 errors, levels of significance, one tailed and 2 tailed tests, application.</p> <p>Chi-test: for independent attributes in rxc table, special case 2x2 table.</p> <p>Students test for significance for correlation, coefficient r for P=0 (small sample tests). Fishers Z transformation coefficient for getting $r_p=0$ in large samples, test of significance for r (p=0).</p> <p>Design of experiment: principles and concepts of completely randomised design, randomized block design and Latin square design.</p> <p>Variance ratio F tests: analysis of variance in one way classification.</p> <p>Non-parametric tests: distribution free methods, sign test for method pairs, Willcoxon test for unpaired data, run test.</p>	
III	<p>Unit III: Instrumentation</p> <p>Spectroscopy: Basic principles, nature of electromagnetic radiation, principles of spectroscopy, types of spectra- absorbance, emission, fluorescence and action spectra, single and double beam spectrophotometers, densitometers, circular dichroism and their applications.</p> <p>Microscopy: Basic principles, instrumentation, sample preparation for optical, phase- contrast, interference, polarisation, inverted, fluorescence, confocal and electron microscopes and their applications.</p> <p>Centrifugation: Principles and types, simple and differential, ultracentrifugation – preparative and analytical.</p> <p>Chromatography: Principle, methodology and applications of chromatography using (paper, thin layer, column(gel filtration, ion exchange, affinity, gas, HPLC,FPLC etc).</p> <p>Electrophoresis: Principles and types of electrophoresis and their applications for proteins, nucleic acids, including gradient gel and pulse-field gel electrophoresis, gel matrices-polyacrylamide, agarose etc, critical parameters for optimum separation and resolution , two dimensional electrophoresis(IEF).</p> <p>X-ray crystallography, Nuclear Magnetic Resonance (NMR) spectra, Magnetic Resonance Imaging (MRI – fMRI) lasers in biology and medicines.</p> <p>Radioisotope methods and tracer techniques in biology: Basic principles of radioactivity, properties and handling of radioisotopes in biology and medicine, radiation units, Geiger- Muller and scintillation counters, autoradiography, radionuclide imaging, CT Scan and PET scan</p> <p>Techniques: Histology, ELISA, RIA, Immunoprecipitation - single and double, Primers, PCR and its types, RFLP, RAPD, AFLP, Blotting techniques: Southern, Western and Northern, In- situ Hybridization: FISH, GISH SKY, Chromosome Painting.</p>	1/ 16L
IV	<p>Unit IV: IPR</p> <p>IPR: Introduction to IPR; Types of Intellectual property – Patents, Trademarks, 12 Copyrights and related rights; Traditional vs. Novelty; Importance of intellectual property rights in the modern global economic environment, Importance of intellectual property rights in India; IPR and its relevance in biology and environmental sciences; Case studies and agreements - Evolution of GATT and</p>	1/ 16L

	<p>WTO and IPR provisions under TRIPS; Madrid agreement; Hague agreement; WIPO treaties; Budapest treaty; Indian Patent Act (1970).</p> <p>Patents: Definition, patentable and non- patentable inventions; types of patent application – Ordinary, Conventional, PCT, Divisional, and Patent of addition; Concept of Prior Art; Precautions while patenting - disclosure / non- disclosure; Time frame and cost; Patent databases, Searching International databases; Patent licensing and agreement; Patent infringement – meaning, scope, litigation, case studies.</p>	
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PRACTICALS: RPSLScP104 (2 credits)

1. Preparation of Phosphate, Tris, and Citrate buffers of various molarity.
2. Determination of lambda max of KMnO₄, CoCl₂, methylene blue by spectrophotometer.
3. Verification of Beer-lamberts law by UV Visible spectrophotometer
4. Separation of amino acids by paper chromatography.
5. Separation of lipids by TLC.
6. Separation of plant pigments by column chromatography.
7. Analyzing the data using Students t-Test, ANOVA and Regression analysis.
8. Case study on an IPR issue.

References:

- Research Methodology in the Medical and Biological Sciences by Petter Laake, Haakon Breien Benestad, Bjorn Reino Olsen (2007, Elsevier_AP)
- Research Methodology - Methods and Techniques by C.R. Kothari (1985, New Age Publications)
- 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)
- Practical biochemistry – Principles and Techniques- Wilson K and Walker J
- Essentials of Biophysics- Narayanan P.
- Analytical Techniques in Biochemistry and Molecular Biology by Rajan Katoch,
- Modern Analytical Biochemistry; Rodney Boyer (3rd Edition)
- Principles of Instrumental Analysis: Skoog
- Methods in Biostatistics- Mahajan P.K
- Law of Intellectual Property Rights-Shiv Sahai Singh
- WTO And Intellectual Property Rights-Talwar Sabanna
- IPR: Unleashing the Knowledge Economy- Prabuddha Ganguli

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.
- Internal exams are further divided as written class tests for 20 marks and assignments for 20 marks depending on the respective topics in each paper.

A) Internal Assessment: 40 Marks

- The class tests are conducted as written or online objective choice based test with google forms. The questions range from simple objective fill ups of 1 mark to complex analytical and applicative based 2-3 marks.
- Assignments include presentations of research papers, articles, case studies, preparation of business plans and debate according to the topics relevant to each papers.
- Students are informed at least a month in advance about the portions for class tests and 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 are the grids showing the internal assessment plan and the rubrics.

INTERNAL ASSESSMENT PLAN		
Semester / Paper	20 mks	20 mks
I	Written Test / online test	Presentation on any research paper / journal article/ newsletter/ book review/ conference/ guest lecture / preparation of business plan/ debate pertaining to syllabus topics chosen or allotted.
II		
III		
IV		

Paper	Marks distribution (Total 20)
I, II, III, IV	Content – 05 mks
	Presentation skills – 05 mks
	Questions answered – 05 mks
	Questions asked – 03 mks
	Time limit – 02 mks

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

Rubrics chart for debate

	Total	80-100%	60-80%	40-60%	20-40%	0-20%
Content	05	5	4	3	2	1
Debate outcome	10	10	8	6	4	2
Manner of conduct	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

1. Duration - These examinations shall be of **2 ½ hrs** duration.
2. 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
I	I, II, III, IV	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
I	1, 2, 3, 4	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 (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)	Theory	60	
	Internals	40	
	Practicals	50	

SEMESTER II

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	L / WEEK
Paper I	Microbiology, Immunology and Plant Physiology			
RPSLSc 201	I	Microbiology	4	4
	II	Immunology		4
	III	Plant physiology I		4
	IV	Plant physiology II		4
Paper II	Model organisms and life processes			
RPSLSc 202	I	Animal Physiology	4	4
	II	Developmental Biology		4
	III	Neurobiology		4
	IV	Model Organisms		4
Paper III	Genetic manipulation and Cell signalling			
RPSLSc 203	I	Gene and Epigenetics	4	4
	II	Gene Expression Regulation		4
	III	Gene cloning		4
	IV	Cell communication and signaling in normal cells and cancer cells		4
Paper IV	Genetic Engineering			
RPSLSc 204	I	Recombinant Techniques	4	4
	II	Microbial Expression Systems		4
	III	Engineering Lower eukaryotes I		4
	IV	Engineering Lower eukaryotes II		4

SEMESTER II
PAPER I
Course Code: RPSLSc201
Course Title: Microbiology, Immunology and Plant Physiology

COURSE OUTCOMES:

COURSE OUTCOME	DESCRIPTION
	At the end of the course students will be able to:
CO 1	Classify microorganisms and understand their growth curve patterns.
CO 2	Recall the secondary metabolites produced by microbes like antibiotics
CO 3	Learn the important aspects of host-parasite interactions.
CO 4	Understand the various immunological processes that are involved in the body's defence system.
CO 5	Understand the mechanisms used by the immune system to fight against viral, bacterial, parasitic infections.
CO 6	Appreciate how plants have developed amazing strategies and mechanisms for survival and growth.
CO 7	Understand how plants see the world through photoreceptors.
CO 8	Gain an insight on plant development and plant cell death.

DETAILED SYLLABUS - Paper I

Course Code : RPSLSc201

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><u>Unit I: Microbiology</u> 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- General characteristics and types. Prokaryotic Cell Structure- Differences between eukaryotic and prokaryotic cells. 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: General characteristics of antimicrobial drugs; Antibiotics: Classification, mode of action and resistance; Antifungal and antiviral drugs. Host Parasite Interaction: Recognition, mechanism of microbial pathogenicity and establishment of disease by different pathogens like viruses, bacteria and parasites into animal hosts (one example each). Nosocomial infection; Emerging infectious diseases; alteration of host cell behavior by pathogens.</p>	1/ 16L
II	<p><u>Unit II: Immunology:</u> 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/ 16L
III	<p><u>Unit III: Plant Physiology I</u> Material transportation: through xylem, phloem and plasmodesmata. Nitrogen metabolism: Symbiotic nitrogen fixation, Ammonia and nitrate uptake and metabolism, amino acid biosynthesis. Plant Hormones: Biosynthesis and biological activity of auxins, cytokinins, gibberellins, Ethylene, Abscissic acid, Salicylates, Jasmonates and Brassinosteroids. Sensory Photobiology: Cryptochromes, phytochromes, phototropins; photoperiodism and biological clocks.</p>	1/ 16L

	<p>Stress response: Plant response to abiotic stress- Water, salt and temperature.</p> <p>Response and resistance to biotic stress (viral, fungal and insects): Host recognition and establishment of disease, overview of plant defense methods (anatomical, secondary metabolites, hypersensitive reactions, hormonal signals and the R - avr system).</p>	
IV	<p>Unit IV: Plant physiology II</p> <p>Plant Development: Role of Phytochromes in plant development including flowering, germination of pollen and self-incompatibility, Double fertilization and seed formation (one typical example of each).</p> <p>Seed germination: The hormonal and nutritional aspect of seed germination.</p> <p>Root and Shoot: Development, organization of root and shoot apical meristems.</p> <p>Leaf development: Development and phyllotaxy, stomatal movement. Flower development: Floral organogenesis and the genes involved: Examples <i>Arabidopsis</i> and <i>Antirrhinum</i>.</p> <p>Programmed Cell Death and Senescence in plants: Concept, effect on pigments in plants, environmental factors and hormonal factors.</p> <p>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>.</p>	1/ 16L

PRACTICALS: RPSLScP201 (2 credits)

1. Diauxic growth curve.
2. Antimicrobial activity by agar cup/ disc method.
3. Sandwich ELISA. (Demonstration), HepElisa/ HCG Kit
4. Semi-quantitative Mancini test.
5. Proline content in normal and saline stressed plants.
6. Effect of Salinity on seed viability.
7. Use of DNA Fluorochromes for studies on pollen grain and pollen tube nuclei.
8. Estimation of Indole Acetic Acid.

References:

- Text book of microbiology: Ananthanarayan and Paniker; Orient blackswan
- Microbiology: Prescott and Dunn
- 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
- Immunology 5th Edition, Janis Kuby; OR Kuby Immunology 7th Edition
- Pollen biology - A laboratory manual, K.R. Shivanna and N.S. Rangaswamy

PAPER II
Course Code: RPSLSc202
Course Title: Model organisms and 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	Understand in depth the physiological aspects of the above life processes in humans.
CO 3	Learn the various disorders arising from defects in physiological processes.
CO 4	Gain in-depth knowledge on the concepts of gametogenesis, fertilization and formation of germ layers during early development processes.
CO 5	Correlate various developmental processes in an organism by understanding the important fundamental concepts of development like commitment, specifications, determination, differentiations, induction, competence, cell fate and lineages with examples.
CO 6	Understand the basics of neuroanatomy and neurocellular mechanisms like electrical & chemical signaling and neurotransmission.
CO 7	Appreciate the advanced functions of the nervous system such as the sensory systems, motor and movement control, behavior, emotions, learning, memory and pain.
CO 8	Recall the life cycles, traditional and new methods for culturing and maintaining model organisms.
CO 9	Select and use the latest databases and computational models of these organisms..

DETAILED SYLLABUS - Paper II

Course Code : RPSLSc202

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><u>Unit I: Animal Physiology:</u></p> <p>Vascular system: Blood corpuscles, hematopoiesis 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/ 16L
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/ 16L
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 neurotransmitters and their receptors; cAMP as messenger, Neuromuscular</p>	1/ 16L

	<p>junctions – structure and function.</p> <p>Sensory systems: Visual, Auditory, Chemosensory, Somatosensory</p> <p>Motor systems – Overview of motor circuits and neural control.</p> <p>Behavior– Reflexive behavior and homeostasis, Associative and non-associative memory.</p>	
IV	<p><u>Unit IV: Model Systems</u></p> <p>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.</p> <p>Nematode worm (<i>Caenorhabditis elegans</i>) - History and description of the model. Culturing and maintenance. Research tools – Wormbase, Wormatlas, Validation of target molecules in C. elegans (genome-wide RNAi, knockouts, compound libraries, HTPS and the MOA strategy)</p> <p>Western clawed frog (<i>Xenopus tropicalis</i>) - Trans-NIH Xenopus Initiative, Xenbase</p> <p>Mouse (<i>Mus musculus</i>) - Model organism for mammalian physiology, Types used for research, The Mouse Knockout & Mutation database.</p> <p>Zebrafish (<i>Danio rerio</i>) - Model organism to study vertebrate physiology and development. Culturing and maintenance. Research tools- Genetic screens with morpholino's. Zebra fish assays. ZFIN database</p>	1/ 16L

PRACTICALS: RPSLScP202 (2 credits)

1. Mounting of cornea and statocyst of prawn.
2. Chick embryology- Fresh Mounting.
3. Neutral red staining for apoptosis in developing chick embryo.
4. Permanent slides of different stages of chick embryo.
5. Microtomy- sections of chick liver and histopathological study.
6. Permanent slides of tissues.
7. Study of ECG and EEG in humans.
8. H&E staining
9. Culturing and imaging C. elegans.

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.
- 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 III
Course Code: RPSLSc203
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 also cell communication and signaling processes.

COURSE OUTCOME	DESCRIPTION At the end of the course students will be able to:
CO 1	Compare the mechanisms of gene expression in prokaryotes and eukaryotes.
CO 2	Identify the components involved in prokaryotic and eukaryotic gene regulation.
CO 3	Recognize the importance and role of various epigenetic factors that affect gene expression and explain the mechanisms involved.
CO 4	Identify various operon systems and explain their detailed mechanism.
CO 5	Understand the post transcriptional and post translational modifications along with the role of various factors involved in both the processes.
CO 6	Gain the knowledge of the various tools used for genetic engineering like restriction enzymes and vectors
CO 7	Apply the concepts of Transformation, Transfection and Transduction methods used for introducing recombinant genes into various host organisms.
CO 7	Understand the various types of cellular signalling, receptors and signalling pathways as well as apoptosis pathways.
CO 8	Identify the stages in cancer progression.
CO 9	Formulate cancer treatment strategies based on the knowledge of cancer physiology.

DETAILED SYLLABUS - Paper III

Course Code : RPSLSc203

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><u>Unit I: Gene and Epigenetics:</u> Structure of Gene: Monocistronic and Polycistronic, Promoter, Operator, ORF, Terminator, Gene families, Pseudogenes, Split Gene. Other elements of Eukaryotic Genome: Satellite DNA, Tandem repeat array, Transposons: LINE and SINE. Genomic Mutations: Introduction, Deletions, Addition, Insertion, Inversions and Translocations. Chromatin Structure: Histones, Non-Histones, Scaffolding proteins. Epigenetics: Hypothesis, Imprinting, Mechanism (Methylation and Acetylation), Cancer epigenetics, Anticipation, Penetrance and Expressivity.</p>	1/ 16L
II	<p><u>Unit II: Gene Expression Regulation:</u> Regulation of Gene expression in Prokaryotes: General aspects of Regulation, transcriptional regulation - inducible and repressible system, positive regulation and negative regulation; Operon concept – lac, trp, Ara operons, the galactose operon, relative positions of Promoters and Operators, Regulons, Master switches, Regulation of Translation, Regulation of the synthesis of Ribosomes, Unregulated changes in gene expression, Feedback Inhibition, RNA interference, mRNA half-life, riboswitches, ribozymes. Regulation of Gene expression in Eukaryotes: Regulatory strategies in Eukaryotes, Transcriptional Control by hormones, signalling factors and environmental factors, Role of transcription factors, enhancers, silencers, chromatin remodelling in regulation of gene expression, role of post-translational modifications of transcription factors, Regulation of processing, Regulation through RNA splicing, RNA degradation and RNA interference, Translational control, Regulation of gene expression in plant cells by light. Diseases associated with defects in regulation.</p>	1/ 16L
III	<p><u>Unit III: Gene cloning</u> Clone: Importance of DNA Cloning, Principles of Cell-based DNA Cloning and cell independent DNA cloning, Cutting and Joining DNA methods, Vectors: Essential components of vectors and their significance, Plasmid vectors, Vectors based on the lambda Bacteriophage, Cosmids, M13 vectors, expression vectors, YACs and BACs. Use of plant viruses as episomal expression vectors. Production of transgenic mice, Embryonic Stem cells for genetically modified mice. Genomic and cDNA libraries. Transfection/Transformation/Transduction (microinjection, electroporation, biolistics): liposome, adenovirus, lentivirus, retrovirus. Protoplasts for gene transfer in eukaryotic and prokaryotic cells.</p>	1/ 16L
IV	<p><u>Unit IV: Cell communication and signaling in normal cells and cancer cells</u> Concept of cell surface receptors, second messengers and regulation of the</p>	1/ 16L

<p>signalling pathway.</p> <p>Signalling pathways: (a). Receptor tyrosine kinases (RTK): EGFR pathway (b). JAK-STAT pathway. (c). G protein coupled receptors. (d). Bacteriorhodopsin signaling. (e). Toll-like receptors (in immunology). (f) Wnt and SHH, Notch</p> <p>Two component signalling: (a). Bacterial – chemotaxis, quorum sensing. (b). Plant two component signalling.</p> <p>Extracellular matrix: Fibres, cell adhesion molecules and their functions, gap junctions.</p> <p>Apoptosis: Concept of programmed cell death, Comparison with necrosis, Function of apoptosis in development and maintenance (formation of digits, removal of old cells etc.); Extrinsic and intrinsic pathways of Apoptosis, effects of aberrant apoptosis.</p> <p>Cancer: As an aberration of the cell cycle; oncogenes, tumor suppressor genes, virus induced cell transformation, metastasis and treatment.</p>	
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PRACTICALS: RPSLScP203 (2 credits)

1. Isolation of plasmid from E. coli.
2. Induction of the Lac operon and assessment of enzyme activity using a suitable system (e.g. E. coli).
3. Isolation of histone from yeast cells.
4. FISH (Demonstration). Visit NIRRH/ others
5. Assessment of signaling pathways in the regulation of nitrate assimilation in plants/ bacteria.

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
Course Code: RPSLSc204
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 techniques such as types of mutagenesis, genome editing using CRISPR/ Cas9, TALENS, the various RNAi methods and metabolic engineering.
CO 2	Select and use different genetic engineering tools and combinations of the above techniques for different applications in the form of expression systems.
CO 3	Optimize various components and essential parameters involved in developing a gene expression system.
CO 4	Compare and analyse various bacterial gene expression systems for both gram positive and gram negative bacterias.
CO 5	Classify various algae types and different techniques for culturing microalgae for biofuel production.
CO 6	Analyse various strategies involved in gene modification of algae for commercial applications.
CO 7	Explain the concept of humanization, analyse various strategies involved in gene modification of fungi for pharmaceutically important secondary metabolite production.
CO 8	Understand the construction of gene knockouts and novel reporter systems.
CO 9	Select and design different components and essential parameters involved in gene expression systems in yeast.
CO 10	Compare and analyse various protozoan gene expression systems.

DETAILED SYLLABUS - Paper IV

Course Code : RPSLSc204

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><u>Unit I: Recombinant Techniques</u> 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, Analysis and detection, applications - modifying activity, substrate specificity, cofactor requirement, increasing stability, pH and temperature optima, Construction of deregulated mutants resistant to feedback inhibition and repression: Examples of modified proteins. 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>, plants and animals, Industrial applications. Systems Biology and Synthetic Biology for strain improvement: Omics analysis, in silico modelling, development of improved strains.</p>	1/ 16L
II	<p><u>Unit II: Microbial Expression Systems</u> Prokaryotic: <i>E. coli</i>: 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/ 16L
III	<p><u>Unit III: Engineering Lower eukaryotes I</u> Algae: Types, Culture systems, Genetic modification - transformation strategies, selection markers, promoters, terminators, translational regulation of protein production, strategies for efficient protein production, applications – increasing photosynthetic efficiency, yield of commercial and therapeutic products, Risks of GM algae. Filamentous fungi – Host strains, transformation strategies, selection markers, promoters, terminators, translational regulation of protein production, strategies for efficient production, signal sequences, gene fusion approach, overproduction of foldases and chaperones, role of glycosylation, heterologous and homologous gene</p>	1/ 16L

	expression, humanization of filamentous fungi (<i>Aspergillus</i> , etc.), applications - pharmaceutically important secondary metabolites, medicinal mushrooms (<i>Ganoderma</i> , etc.), polysaccharides from basidiomycetes for immunostimulating and anticancerous activity.	
IV	<p><u>Unit IV: Engineering Lower eukaryotes II</u></p> <p>Yeasts: Yeast Selectable Markers and Vector Systems, commercially used yeast 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: Analysis of Genes, Genomes and Protein- Protein Interactions - 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>	1/ 16L

PRACTICALS: RPSLScP 204 (2 credits)

1. Isolation of plasmid DNA from *E. coli*.
2. Transformation of *E. coli* and blue-white colony screening.
3. Isolation of Protease degraders from soil and estimation of the protease activity.
4. Preparation and regeneration of fungal protoplast.
5. Detection and estimation of gene copy number by real time PCR (demonstration).
6. Transformation of Yeast
7. Slide culture of filamentous fungi with nuclei tracking using DAPI stain.
8. Replica Plating.
9. Restriction Fragment Length Polymorphism (RFLP).

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

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.
- Internal exams are further divided as written class tests for 20 marks and assignments for 20 marks depending on the respective topics in each paper.

A) Internal Assessment: 40 Marks

- The class tests are conducted as written or online objective choice based test with google forms. The questions range from simple objective fill ups of 1 mark to complex analytical and applicative based 2-3 marks.
- Assignments include presentations of research papers, articles, case studies, preparation of business plans and debate according to the topics relevant to each papers.
- Students are informed at least a month in advance about the portions for class tests and 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 are the grids showing the internal assessment plan and the rubrics.

INTERNAL ASSESSMENT PLAN		
Semester II Paper	20 mks	20 mks
I	Written Test / online test	Presentation on any research paper / journal article/ newsletter/ book review/ conference/ guest lecture / preparation of business plan/ debate pertaining to syllabus topics chosen or allotted.
II		
III		
IV		

Paper	Marks distribution (Total 20)
I, II, III, IV	Content – 05 mks
	Presentation skills – 05 mks
	Questions answered – 05 mks
	Questions asked – 03 mks
	Time limit – 02 mks

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

Rubrics chart for debate

	Total	80-100%	60-80%	40-60%	20-40%	0-20%
Content	05	5	4	3	2	1
Debate outcome	10	10	8	6	4	2
Manner of conduct	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

1. Duration - These examinations shall be of **2 ½ hrs** duration.
2. 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
II	I, II, III, IV	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
II	1, 2, 3, 4	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 II**

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)	Theory	60	
	Internals	40	
	Practicals	50	

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SEMESTER III

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	L / WEEK
Paper I	Tissue culture and Aquaculture			
RPSLSc 301	I	Plant Tissue Culture	4	4
	II	Transgenic Plants		4
	III	Animal Tissue Culture		4
	IV	Aquaculture		4
Paper II	Fermentation Technology and its Applications			
RPSLSc 302	I	Upstream and Downstream Processes	4	4
	II	Fermentation process I		4
	III	Fermentation process II		4
	IV	Enzymes in Industry		4
Paper III	Bioinformatics, International Standards & Bioethics			
RPSLSc 303	I	Bioinformatics	4	4
	II	Alignment problem and solutions		4
	III	ISO, GMP & GLP		4
	IV	Bioethics and Entrepreneurship		4
Paper IV RPSLSc 304	Project Work			6

SEMESTER III

PAPER I

Course Code: RPSLSc301

Course Title: Tissue culture and Aquaculture

COURSE OUTCOMES: This course deals with introducing the techniques, principles and practical considerations of plant tissue culture, animal tissue culture, aquaculture as well as the production of transgenic plants and animals using these techniques.

COURSE OUTCOME	DESCRIPTION At the end of the course students will be able to:
CO 1	Gain knowledge of the technological aspects of plant tissue culture which have direct industrial and commercial applications in agriculture, horticulture, crop improvement and secondary metabolite production.
CO 2	Develop skills to prepare plant tissue specific media, sterilize and inoculate explants and maintain cultures in the laboratory
CO 3	Apply the knowledge of stress physiology in the development of resilient transgenic plants to be used in agriculture.
CO 4	Understand the key concepts of animal tissue culture such as culturing principles, techniques, applications.
CO 5	Identify the various types of contamination that occurs during tissue culture and ways to control them.
CO 6	Gain knowledge of the various culturing practices, factors that affect optimum growth of aquatic organisms.
CO 7	Understand the scope of aquaculture as a lucrative business.
CO 8	Evaluate the state of aquaculture in India and the world.

DETAILED SYLLABUS - Paper I

Course Code : RPSLSc301

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><u>Unit 1 - Plant Tissue Culture</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>Haploid Production: Androgenesis, Gynogenesis, Applications</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>	1/ 16L
II	<p><u>Unit II: Transgenic Plants</u></p> <p>Recombinant technology: Plant transformation by <i>Agrobacterium tumefaciens</i> [including mechanism of T DNA transfer in wild type <i>Agrobacterium</i>], <i>A. rhizogenes</i> its plasmid, Biolistic: factors that influence transformation success,</p> <p>Applications of transgenic: Overview, Recombinant proteins of pharmaceutical importance in plants including vaccine subunits, edible vaccines, from hairy root cultures.</p> <p>Transgenic plants: Strategies for virus resistance, Herbicide resistance, Insect resistance, nematode infections and resistance, stress resistance [salt, water and temperature], Improved nutrition [carbohydrate, protein], improved shelf life; Novel applications: change in lipid profile for industrial purpose, biodegradable plastics, novel horticultural traits [flower colour, variegation].</p>	1/ 16L
III	<p><u>Unit III: 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 cultivation- cytodex and bio fermenters.</p>	1/ 16L

	Applications: Stem cells & therapeutic cloning, Tissue engineering and 3D printing.	
IV	<p><u>Unit IV: Aquaculture</u></p> <p>Aqua culture technology: definition, history and scope, constraints and recent development, criteria for selection of species, aquafarm engineering.</p> <p>Pisciculture: cultivable fish species, seed production technology of carps, carps culture, mono and poly culture.</p> <p>Prawn culture: cultivable prawn species, spawning techniques, culture methods in India.</p> <p>Pearl oyster culture: pearl producing species, pearl culture technology, composition of pearl quality and prospects.</p> <p>Seaweed culture: economically important species culture and post harvest technology.</p>	1/ 16L

PRACTICALS: RPSLScP301 (2 credits)

1. Micropropagation of selected ex-plants.
2. Production of artificial seeds.
3. Preparation of plant protoplasts.
4. RAPD analysis (plants/ bacteria).
5. Establishment of Primary Culture (ATC) using a suitable source.
6. Identification of cultivable fish species.
7. Identification of cultivable prawn species.
8. Identification of cultivable pearl bivalves and oyster species.
9. Identification of cultivable seaweed species.
10. Isolation and determination of colony characteristics of marine organisms.

References:

1. Aquaculture by Ujwala Jadhav
2. Principles of Biochemistry by Lehninger, Nelson and Cox
3. Introduction to plant tissue culture by M. K. Razdan
4. Animal Cell Culture by Ian Freshney
5. Basic Cell Culture by J. M. Davis.

PAPER II
Course Code: RPSLSc302
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	Gain knowledge behind the fundamental concepts of fermentation techniques.
CO 2	Differentiate between various types of fermenters.
CO 3	Design the components and optimize various essential parameters required in a fermenter.
CO 4	Identify and analyse techniques of isolation, preservation of microbial cultures and various fermentation media used for optimum production.
CO 5	Derive microbial growth kinetics for fermentation processes and optimize the culture conditions to scale up the production.
CO 6	Understand the concepts and methods used for product recovery, the associated product economics and explain the importance of effluent treatment.
CO 7	Describe various fermentation processes of commercial importance such as cheese, alcohol, acid, single cell protein to name a few.
CO 8	Understand the types of secondary metabolites and biochemical pathways.
CO 9	Classify the secondary metabolites according to their structure.
CO 10	Get an insight into the industrial production of specific examples like Taxol.
CO 11	Enlist the scope of enzymes in various commercial industrial productions of food, nutraceuticals, and other essentials.

DETAILED SYLLABUS - Paper II

Course Code : RPSLSc302

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/ 16L
II	<p><u>Unit II: Fermentation process I</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: 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>Flavour/fragrance production with example.</p>	1/ 16L
III	<p><u>Unit III: Fermentation Process II</u></p> <p>Secondary metabolites production from plants: Secondary metabolite types (alkaloids, terpenes [include IPP synthesis: Classic pathway and Alternate pathway for IPP synthesis in plastids], tannins, lignans pigments, lipids); Selection of callus cultures.</p> <p>Examples of secondary metabolite production (industrial scale): [shikonin, taxol</p>	1/ 16L

	(biosynthesis and bioreactor production) capsaicin/ berberine]. From microbes: Polymers [dextrans, xanthan gums, alginate], antibiotics [peptide, lantibiotics, aminoglycosides, beta lactam], cyclosporins, biosurfactants.	
IV	<u>Unit IV: Enzymes in Industry</u> Industries: Textile Processing, Leather Processing, Paper & Pulp Processing, Detergents and laundry. Food biotechnology: Fruit and vegetable processing: juices, nectars, purees; syrup and glucose isomerases, enzymatic synthesis of aspartame. Other industrial uses: Vinegar, Baking, Cocoa fermentation, Olive oil production, fish processing industries. Nutraceuticals: Probiotics: lycopene, isoflavonoids, glucosamine, phytosterol. Feed Biotechnology: lignocelluloses into feed using cellulases, silage. Bio preservation: chemical preservatives and their safety concerns, LAB Bacteriocins. Types of bacteriocins, mode of action, applications and regulations.	1/ 16L

PRACTICALS: RPSLScP302 (2 credits)

1. Immobilization of cells.
2. Demonstration of fermenter/ chemostat.
3. Estimation of alcohol production: Sucrose/ fruit (s)/ sugarcane juice.
4. Isolation of cellulase producing microorganisms from natural source(s).
5. Determination of cellulose activity using Filter paper assay/ carboxy-methyl cellulose assay.
6. Secondary metabolite production using plant tissue culture (dye/ drug Alkaloids etc.)
7. Effect of elicitor(s) on the production of the plant secondary metabolite.
8. Estimation of tannins using the Vanillin Hydrochloride method.
9. Isolation and estimation of Nutraceuticals (lycopene/ isoflavonoids) by TLC.

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 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	Appreciate the various internet protocols that are involved in a single mouse click.
CO 2	Classify the biological databases that are used in bioinformatics and research in general.
CO 3	Select and use the appropriate biological database according to the query.
CO 4	Understand the concept of multiple sequence alignment and various methods along with the pairwise sequence alignment.
CO 5	Select and use the appropriate software to carry out multiple and pairwise alignment.
CO 6	Understand the concept, terminologies, types and properties of phylogenetic trees and the various methods of building it.
CO 7	Construct phylogenetic trees manually as well as computationally.
CO 8	Get an insight on the importance of the ISO standards as well as the GMP and GLP guidelines.
CO 9	Know the requirements and procedure of these certifications which may provide a basis for a future career in quality assurance, quality management or auditing.
CO 10	Understand how to set up their own businesses and be their own bosses and take examples and inspiration from successful Indian bio-entrepreneurs.
CO 11	Write a successful business plan and investment proposal.
CO 11	Bridge the gap between the laboratory and the commercial marketplace.
CO 12	Understand the relevance of bioethics in regulating exciting developments in biology and medicine.
CO 13	Debate on various topics involving bioethics as it gives a unique perspective on both sides of an issue.

DETAILED SYLLABUS - Paper III

Course Code : RPSLSc303

Unit	Course/ Unit Title	Credits/ Lectures
I	<p><u>Unit I: Bioinformatics</u></p> <p>Introduction to Bioinformatics: 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>Introduction to Data Mining: Types of Data (Text formats, sequence data, protein structures, links), Data mining and warehousing, Process of knowledge discovery through data mining.</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>	1/ 16L
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, Neighbor-Joining Method, Maximum Parsimony.</p>	1/ 16L
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> <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>	1/ 16L

	Case studies for SOP preparation and CAPA (Corrective action Preventive Action).	
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; Basic Approaches to Ethics, Bioethics: legal and regulatory issues; Bioethics in healthcare, agriculture, modern biology, biotechnology, animal welfare & right / animals in research, wildlife conservation and management, commercialism in scientific research, Past and Present ‘Bioethical Conflicts’ in Biotechnology- Interference with Nature , Fear of Unknown, Regulatory Concerns, Human Misuse Future ‘Bioethical Conflicts’ in Biotechnology - Changing perception of Nature, Human Genetic Engineering, GMOs.</p> <p>Entrepreneurship - Emerging trends in biotechnology industry, organizational structure, funding and investment, Demand, markets, viability, licensing, collaboration and technology transfer. Bioentrepreneurship in Rural and Urban India, Business ethics and government policy, Social entrepreneurship.</p>	1/ 16L

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. Fundamentals of Bioinformatics: Harisha S.
5. Bioinformatics and Molecular Evolution: Higgs & Attwood
6. Bioinformatics: Harshwardhan Pal
7. Economics of Biotechnology by T.V.S Rama Mohan Rao
8. Entrepreneurship and Business of Biotechnology by S. N. Jogdand
9. Economic dynamics of Modern Biotechnology by Maureen D. McKelvey, Annika Rickne, Jens Laage-Hellman

PAPER IV
Course Code: RPSLSc304
Course Title: Project Work

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	Present their work in the form of oral or poster presentations at the national or international conferences if deemed suitable by their research guides.
CO 7	Publish their work in research journals approved by the new UGC CARE list.

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.
- Internal exams are further divided as written class tests for 20 marks and assignments for 20 marks depending on the respective topics in each paper.

A) Internal Assessment: 40 Marks

- The class tests are conducted as written or online objective choice based test with google forms. The questions range from simple objective fill ups of 1 mark to complex analytical and applicative based 2-3 marks.
- Assignments include presentations of research papers, articles, case studies, preparation of business plans and debate according to the topics relevant to each papers.
- Students are informed at least a month in advance about the portions for class tests and 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 are the grids showing the internal assessment plan and the rubrics.

INTERNAL ASSESSMENT PLAN		
Semester III, Paper	20 mks	20 mks
I	Written Test / online test	Presentation on any research paper / journal article/ newsletter/ book review/ conference/ guest lecture / preparation of business plan/ debate pertaining to syllabus topics chosen or allotted.
II		
III		

Paper	Marks distribution (Total 20)
I, II, III	Content – 05 mks
	Presentation skills – 05 mks
	Questions answered – 05 mks
	Questions asked – 03 mks
	Time limit – 02 mks

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

Rubrics chart for debate

	Total	80-100%	60-80%	40-60%	20-40%	0-20%
Content	05	5	4	3	2	1
Debate outcome	10	10	8	6	4	2
Manner of conduct	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

1. Duration - These examinations shall be of **2 ½ hrs** duration.
2. 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	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 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	Q1. Major experiment	30
		Q2. Identification	10
		Q3. <i>Viva voce</i>	5
		Q4. Journal	5
Total marks			50

Semester	Paper	Question	Total marks
III	4	Q1. Literature review / Project presentation and black book	30
		Q2. <i>Viva voce</i>	20
Total marks			50

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

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 (100 marks)	Theory	60	
	Internals	40	
IV (200 marks)	Project Report	100	
	Project presentation	50	
	Project Practical work	50	

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

SEMESTER IV

COURSE CODE	UNIT	TOPIC HEADINGS	CREDITS	L / WEEK
Paper I	Medical Biotechnology			
RPSLSc 401	I	Therapeutics I	4	4
	II	Therapeutics II		4
	III	Activity Guided Drug Development		4
	IV	Pharmacogenomics and Drug design		4
Paper II	Applied Biotechnology			
RPSLSc 402	I	Assisted reproductive technology	4	4
	II	Nanotechnology		4
	III	New Emergent Technologies		4
	IV	Diagnostics and Forensics		4
Paper III	Environmental Biotechnology			
RPSLSc 403	I	Biological Controls and Biopesticides	4	4
	II	Nitrogen Fixation and Biofertilizers		4
	III	Bioremediation		4
	IV	Phytoremediation and phytomining		4
Paper IV	Protein studies, Advanced Bioinformatics and Biomathematics			
RPSLSc 404	I	Protein Trafficking and Targeting	4	4
	II	Protein folding and Biomolecular interactions		4
	III	Advanced Bioinformatics		4
	IV	Biomathematics		4

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, production and examples of gene therapy, antisense therapy and protein therapeutics. Learn the classification, production methods and applications of therapeutic proteins which are engineered proteins that have revolutionized the field of medicine and diagnostics.
CO 2	Know the strategies of applying gene therapy or antisense therapy to combat various diseases.
CO 3	Understand the important new concepts in engineering of vaccines and peptibodies and their applications for various diseases.
CO 4	Know the steps involved in drug designing right from identification of the API in activity guided drug development to its metabolism and action.
CO 5	Get an insight into pharmaceutical research and the journey of a drug before it reaches the market.
CO 6	Evaluate disease models used for developing new therapeutics, and computational models for rational drug design.
CO 7	Assess the pharmacogenomics of various illnesses like cancer syndromes, neuropsychotic and cardiovascular disorders.

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/ 16L
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, Antidiotypes, 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> <p>Biosimilars: Definition, design, features, analysis and application.</p>	1/ 16L
III	<p><u>Unit III: Activity Guided Drug Development</u></p> <p>Plant collection and Extract preparations: Methods of Plant collection, solvent</p>	1/ 16L

	<p>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>	
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, neuropsychotic 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/ 16L

PRACTICALS: RPSLScP401 (2 credits)

1. Residual DNA analysis of recombinant therapeutic protein.
2. Multiplex PCR
3. Pedigree analysis (disease/disorder/trait)
4. Bioautography for antimicrobial and antioxidant activity.

References:

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

PAPER II
Course Code: RPSLSc402
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	Gain an understanding of 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.
CO 3	Understand the synthesis and characterization of nanomaterials as well novel areas of research in the field.
CO 4	Synthesize silver, zinc oxide and ferromagnetic nanoparticles in the laboratory and determine their biological activity.
CO 5	Recognize the various concepts of the new emerging technologies.
CO 6	Gain knowledge in designing a microfluidics systems by analysing various parameters and its applications.
CO 7	Realize the concept of Biomimetics and its various commercial applications.
CO 8	Understand the basics of forensic science and also perform simple experiments like hair microscopy to put their investigative and deducing skills to the test.
CO 9	Identify the ways to create an accurate, quick but cost effective diagnostic kit for a certain disorder or infection.
CO 10	Understand the importance of diagnostics and its applications.

DETAILED SYLLABUS - Paper II

Course Code : RPSLSc402

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/ 16L
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 bionanoparticles: 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/ 16L
III	<p><u>Unit III: New emergent Technology</u></p> <p>Biosensors: Concepts. Types of biosensors: amperometric, potentiometric, conductometric, calorimetric, piezoelectric, 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/ 16L

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/ 16L
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PRACTICALS: RPSLScP402 (2 credits)

1. Synthesis of silver nanoparticles - biological method.
2. Preparation of gold nanoparticles, ferromagnetic fluid, corn flour non Newtonian fluid
3. Antimicrobial activity of SNP by the tetrazolium microplate assay.
4. Antioxidant activity of SNP.
5. Demonstration of Laminar Flow in Microfluidic system
6. Hair microscopy for forensic analysis.
7. PAGE of DNA samples and silver staining.

References:

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

PAPER III
Course Code: RPSLSc403
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	Know the challenges of pests to agriculture and the biological alternatives to harmful chemical pesticides.
CO 2	Understand the mode of action and mass production of biological pesticides.
CO 3	Appreciate the importance of Integrated Pest Management in order to sustain the least amount of crop damage while maintaining pest populations.
CO 4	Compare the use of chemical fertilizers with biological alternatives and the use of genetic engineering to improve nitrogen fixation.
CO 5	Gain an understanding of soil enriching techniques like composting, the ecological role of mycorrhiza and the emerging technique of aquaponics.
CO 6	Get sensitized towards the issue of Solid Waste Management, associated laws and regulations, current status of the steps taken by the government like the 'Swachh Bharat Abhiyaan'.
CO 7	Understand the concept of Bioremediation, explain various adaptive mechanisms for pollutant tolerance by microbes and apply for environmental protection.
CO 8	Understand the role of various species of plants in phytoremediation, phytoremediation types, steps involved in the process and a plant's inherent detoxification mechanisms.
CO 9	Understand the lucrative technique of phytomining of precious metals like gold and the economics of the process.

DETAILED SYLLABUS - Paper III

Course Code : RPSLSc403

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 pyrethrins, 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/ 16L
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/ 16L
III	<p><u>Unit III: Bioremediation</u></p> <p>Solid management: Types, need, unit processes, laws and regulations.</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 with examples. Heaps. Dumps and biomineralization</p>	1/ 16L

IV	<p><u>Unit IV: Phytoremediation and phytomining</u></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/ 16L
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PRACTICALS: RPSLScP403 (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.

References:

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

PAPER IV**Course Code: RPSLSc404****Course Title: Protein Studies, Biomathematics and Advanced Bioinformatics.****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 in order to carry out all the metabolic processes.
CO 4	Understand the concepts and advanced softwares used in the field of proteomics and genomics 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	Gain an insight on the importance of maths which is required to understand ecological modelling, growth curves, population genetics, epidemic modelling, enzyme kinetics, analysing drug efficacies as well as cancer treatment modelling to name a few.
CO 7	Solve basic calculus problems as well as examples in biological scenarios.

DETAILED SYLLABUS - Paper IV

Course Code : RPSLSc404

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/ 16L
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/ 16L

III	<p><u>Unit III: Advanced Bioinformatics</u></p> <p>Genomics: Basic concepts on identification of disease genes, role of bioinformatics-OMIM database, reference genome sequence, integrated genomic maps, gene expression profiling; identification of SNPs, SNP database (DbSNP). Role of SNP in Pharmacogenomics, SNP arrays.</p> <p>Proteomics: Introduction and current status, Prediction of secondary structure: PHD and PSI-PRED method. Tertiary (3-D) Structure prediction: Fundamentals of the methods for 3D structure prediction (sequence similarity/identity of target proteins of known structure, fundamental principles of protein folding etc.) Homology Modelling (Ramchandran plot), fold recognition, threading approaches, and ab-initio structure prediction methods. Application in drug designing: Drug targets, Lead Identification and Modification, Computer-Aided Drug Design.</p>	1/ 16L
IV	<p><u>Unit IV: Biomathematics</u></p> <p>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) Application of integration to find area, Differential equations - - homogeneous and Linear ODE's and its simple applications to biological problems. Applications of maths in biology.</p>	1/ 16L

PRACTICALS: RPSLScP404 (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* drug designing using Click2Drug and Autodock4.
5. Motif Finding- MEME and TomTom
6. Secondary Structure Prediction: Porter 5.0
7. Tertiary Structure: ExPasy in SWISS

References:

1. Principles of Biochemistry by Lehninger, Nelson and Cox
2. Biochemistry by Stryer
3. Biochemistry by Harper
4. ISO 9000 quality systems handbook fourth edition by David Hoyle
5. International standard ISO 9001: quality management systems requirements 5th edition 2015-09-15.
6. Jürg P. Seiler - Good Laboratory Practice - the Why and the How (2005, Springer)
7. Good Manufacturing Practices and Inspection volume 2 (2007, World Health Organization)
8. GLP Essentials - A Concise Guide to Good Laboratory Practice by Milton A. Anderson - (2002, CRC Press).

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.
- Internal exams are further divided as written class tests for 20 marks and assignments for 20 marks depending on the respective topics in each paper.

A) Internal Assessment: 40 Marks

- The class tests are conducted as written or online objective choice based test with google forms. The questions range from simple objective fill ups of 1 mark to complex analytical and applicative based 2-3 marks.
- Assignments include presentations of research papers, articles, case studies, preparation of business plans and debate according to the topics relevant to each papers.
- Students are informed at least a month in advance about the portions for class tests and 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 are the grids showing the internal assessment plan and the rubrics.

INTERNAL ASSESSMENT PLAN		
Semester IV, Paper	20 mks	20 mks
I	Written Test / online test	Presentation on any research paper / journal article/ newsletter/ book review/ conference/ guest lecture / preparation of business plan/ debate pertaining to syllabus topics chosen or allotted.
II		
III		
IV		

Paper	Marks distribution (Total 20)
I, II, III, IV	Content – 05 mks
	Presentation skills – 05 mks
	Questions answered – 05 mks
	Questions asked – 03 mks
	Time limit – 02 mks

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

Rubrics chart for debate

	Total	80-100%	60-80%	40-60%	20-40%	0-20%
Content	05	5	4	3	2	1
Debate outcome	10	10	8	6	4	2
Manner of conduct	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

1. Duration - These examinations shall be of **2 ½ hrs** duration.
2. 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, IV	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
IV	1, 2, 3, 4	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 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)	Theory	60	
	Internals	40	
	Practicals	50	
