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

# S. P. Mandali's

# Ramnarain Ruia Autonomous College

RUIA COLLEGE
Explore • Experience • Excel

## Syllabus for Masters of Science

## Program: M.Sc. Life Science

## Program Code: RPSLSc

(Credit Based Semester and Grading System for academic year 2021–2022)

# 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<br><br>**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<br><br>**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** | Follow good laboratory etiquettes and research ethics. |
| **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 biotechnology to nanotechnology or become self-sustaining bio-entrepreneur. |
| **PSO 8** | Showcase their creativity and express their ideas in a nurturing environment. |

# MSc Life Science Program Outline

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

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

The MSc syllabus is also designed keeping in mind the highly competitive 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 endeavours.

# PROGRAM OUTLINE

| YEAR | SEM | COURSE CODE* | COURSE TITLE | CREDITS |
|---|---|---|---|---|
| 2021-22 | 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 |

** Click on the code to go to the corresponding page for that paper.*

# 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, 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<br>**At the end of the course students will be able to:** |
|---|---|
| **CO 1** | Understand ecological concepts, environmental issues, the value of biodiversity, the importance of conservation, biological theories and concepts in evolution which forms the basis of phenomena like antibiotic resistance as well as cancer progression. |
| **CO 2** | Apply ecological concepts to their day-to-day life in order to benefit the environment and use various essential software that will help them in their respective careers. |
| **CO 3** | Identify the major events and dates that provide the structure for geologic time on Earth. |
| **CO 4** | Analyse the age of fossils with the help of radio dating techniques. |
| **CO 5** | Assess the possibilities of biological lifeforms evolving in outer space. |
| **CO 6** | Design a fully functional website of their choice. |

# DETAILED SYLLABUS - Paper I

**Course Code/ Unit : RPSLSc101**

| Unit | Course/ Unit Title | Credits/ Lectures |
|---|---|---|
| I | **Unit I: Environmental biology**<br><br>**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.<br>**Community ecology:** Nature of communities; fundamental properties of biological communities (Productivity, Diversity, Complexity, Resilience, Stability, Structure); levels of species diversity and its measurement (Simpson, Shannon and Sorensen indices); edges and ecotones, Succession, disturbances and invasion.<br>**Population ecology:** Characteristics of a population; population growth curves; population regulation; life history strategies (r and K selection); concept of metapopulation, demes and dispersal.<br>**Environmental health:** Environmental stress and adaptation, effects of pollution on living systems, environmental pollutants related human disorders, Climate change<br>**Toxicology:** Basic principles of toxicology including LD50 and ED50, management of acute intoxication. | 1/ 15L |
| II | **Unit II: Biodiversity Management and GMOs**<br><br>**Biodiversity:** Concept, characterization, generation, maintenance and loss, Magnitude and distribution of biodiversity, economic value, bioprospecting, ecotourism and biodiversity management approaches. Biodiversity of India.<br>Species interactions: Types of interactions, interspecific competition, herbivory, carnivory, pollination, symbiosis.<br>**Conservation biology:** Principles of conservation, major approaches to management, conservation strategies and cryopreservation.<br>**Genetically modified organisms (GMOs):** Definition of GMOs, applications in food and agriculture, Release of GMO in environment – risk analysis, risk assessment and risk management,<br>**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. | 1/ 15L |

| | | |
|---|---|---|
| **III** | **Unit III: Evolution**<br>**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<br>**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.<br>**Molecular Evolution:** Concepts of neutral evolution, molecular divergence and molecular clocks; origin of new genes and proteins; gene duplication and divergence, molecular taxonomy.<br>**Astrobiology:** Concepts, planetary habitability, extremophiles, abiogenesis, research on surviving extreme habitats, evolution of advanced life, astrobiology of Mars. | **1/ 15L** |
| **IV** | **Unit IV: Use of Software in Research**<br><br>**Literature Search:** Query formulation, PubMed, NCBI, Google Scholar, Shodganga, etc. Paywalls and smart search engines.<br>**Word Processing systems,** Microsoft Word, Google Docs, LATEX**.**<br>**Image Editors:** Guidelines for publishing images, Adobe Photoshop, Image J.<br>**Referencing:** Mendeley, EndNote, Zotero.<br>**Graphing & Statistics:** Microsoft Excel, Google Sheets, GraphPad Prism, MaxStat, IBM SPSS, R.<br>**Anti Plagiarism:** Grammarly, TurnItIn, Online plagiarism checkers.<br>**Presentation and Design:** Microsoft PowerPoint, Google Slides, Microsoft Publisher.<br>**Website building –** Wix website design and publishing.<br>**Miscellaneous:** Using Cloud tools, Microsoft OneNote, Lightshot, Google lens. | **1/ 15L** |

**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. Analysing the floral origin of pollen grains in honey.

**References:**


- The Cambridge Encyclopedia of Human Evolution (Cambridge Reference Book) by Steve Jones
- Evolution by Monroe W. Strickberger, CBS publishers and distributors
- Astrobiology: An Introduction by Alan Longstaff, CRC Press.
- Astrobiology: A brief introduction by Kevin W. Plaxco and Michael Gross, The Johns Hopkins University Press.
- Biodiversity, Wilson E.O. (Ed.), National Academy Press, Washington, D. C.
- Understanding Biodiversity by David Zeigler (May 30, 2007): Amazon Press
- Fundamentals of Ecology by E.P. Odum, Cengage publishers
- Ecology and environment by P.D. Sharma, Rastogi publications
- Elements of Ecology by Smith and Smith, Pearson publishers
- Environmental Biology edited by Mike Calver*et al*: Cambridge University Press
- Molecular Environmental Biology by Seymour J. Garte, Lewis Publishers (1994)
- Basic Environmental Toxicology, Lorris G. Cockerham& Barbara S. Shane, CRC Press.
- 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<br>**At the end of the course students will be able to:** |
|---|---|
| **CO 1** | Understand basic in-depth fundamentals of cellular structure, components and their functions. Explain the importance of cell cycle in growth and development of an organism as well as the principles of the inheritance pattern of genes. |
| **CO 2** | Recall the detailed events of one of the highly coordinated processes of the cell cycle, its role, regulation and checkpoints. |
| **CO 3** | Employ gene mapping methods to find the distance between genes. |
| **CO 4** | Compare the mechanisms involved in DNA replication, recombination and repair in prokaryotes and eukaryotes. |
| **CO 5** | Appraise the concepts of the central dogma of life from DNA to RNA to proteins which serve the whole purpose of molecular biology. |
| **CO 6** | Employ creative media in assignments to express the concepts learnt. |

# DETAILED SYLLABUS - Paper II

## Course Code : RPSLSc102

| Unit | Course/ Unit Title | Credits/ Lectures |
|---|---|---|
| I | **Unit I: Cell Biology**<br><br>**Plasma membrane:** Structure and composition, Membrane properties, Functions and Membrane models.<br>**Endoplasmic reticulum:** Structure and function of Rough and smooth ER.<br>**Golgi complex:** Structure and function, Cisternal progression theories**.**<br>**Nucleus:** Structure - Nuclear envelope, Nuclear pore complex & Nuclear lamin proteins, Functions, Chromatin - Heterochromatin, Euchromatin, Packaging and models<br>Nucleolus - Structure and function.<br>**Other organelles:** Lysosomes, peroxisomes, mitochondria, chloroplasts and vacuoles.<br>**Cytoskeleton:** Structure, Assembly & Functions of Microtubules, Intermediate filaments (types) & Microfilaments.<br>**Introduction to cell cycle:** Stages of the cell cycle – G0, G1, S, G2 and M.<br>Molecular events in the various cell cycle stages (Yeast / Mammalian)**.**<br>**Checkpoints** (unreplicated DNA, spindle attachment, segregation of chromosomes, DNA Damage)<br>**Concept of cyclin and CDKs; activation of the cyclin-CDK complexes (Yeast / Mammalian).**<br>**G1 cyclins:** Cln1, Cln2 and Cln3 and its relevance in commitment to cell division.<br>**S phase and G2 phase:** S phase cyclin, its inhibitors and pre-replication complex and its significance in DNA replication in the cell cycle.<br>**M phase:** Prophase, Metaphase, Anaphase and Telophase, condensins, securin, separase and the end of mitosis.<br>Meiosis checkpoints (Ime2, Rec8 and monopolin) | 1/ 15L |
| II | **Unit II: Genetics:**<br>**Extensions of Mendelian principles:** Codominance, incomplete dominance, Multiple alleles, Lethal and Essential Genes.<br>**Non Mendelian Inheritance:** Cytoplasmic inheritance, organelle genetics, maternal inheritance.<br>**Microbial genetics:** transformation, conjugation, transduction and sex-duction, mapping genes by interrupted mating.<br>**Quantitative genetics:** Pleiotropy and epistasis, polygenic inheritance, heritability and its measurements, QTL mapping, linkage and crossing over.<br>**Population Genetics:** gene pool, gene frequency, Hardy Weinberg Law and its role in evolution and speciation, Pedigree analysis. | 1/ 15L |

| | | |
|---|---|---|
| | **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.<br>**Human Genome Project, SNPs and Genome wide association studies.** | |
| **III** | **Unit III: DNA Replication, Repair and Recombination**<br><br>**DNA replication:** DNA structure, forms of DNA, Unit of replication and enzymes, replication origin and replication fork, fidelity and processivity of replication, extrachromosomal replicons (plasmid). Replication process in prokaryotes and eukaryotes.<br>**DNA repair mechanisms:** SS damage reversal repair, SS damage excision repair (BER, NER, MMR), DS damage repair (HR, NHEJ, NMEJ), Defects in DNA repair. | **1/ 15L** |
| **IV** | **Unit IV: Transcription and Translation**<br><br>**Transcription:** Classes of RNA molecules - structure and function.<br>**Transcription in prokaryotes:** E. coli RNA polymerase, transcription activators and repressors, initiation, elongation and termination, processing of tRNA and rRNA in E. coli.<br>**Transcription in Eukaryotes** - Types of eukaryotic RNA Polymerases, mRNA transcription - formation of initiation complex, elongation & termination, Upstream activation sites and enhancers, mRNA processing and modifications - capping & polyadenylation, mRNA Splicing, RNA editing, RNA Pol II & Pol III promoters, Eukaryotic rRNA genes, rRNA synthesis & processing, formation of eukaryotic tRNA molecules.<br>**Translation:** Outline of Translation.<br>**The Genetic Code:** The Decoding System, Codon -Anticodon interaction.<br>**Ribosomes:** the special properties of the prokaryotic and eukaryotic ribosomes, ribosome biogenesis.<br>**Translation process:** initiation, elongation and termination factors of prokaryotes and eukaryotes mechanisms to overcome premature translation termination, role of suppressor tRNAs.<br>**Inhibitors of protein synthesis:** Prokaryotic and eukaryotic protein synthesis inhibitors and their significance. | **1/ 15L** |

**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.

**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<br>**At the end of the course students will be able to:** |
|---|---|
| **CO 1** | Investigate the unique properties of amino acids which influences the amazing diversity of proteins. |
| **CO 2** | Relate the basic concepts in protein biochemistry to advanced subjects like protein engineering, vaccine formulation and drug designing. |
| **CO 3** | Understand the structure and properties of lipids and study the pathways and mechanisms involved in ATP synthesis in plants and animals. |
| **CO 4** | Recall the classification, structural properties of carbohydrates along with the concept of stereochemistry and biological roles. |
| **CO 5** | Evaluate the structure, and role of vitamins and minerals and explain their importance with respect to nutritional deficiencies. |
| **CO 6** | Construct the graphs depicting enzyme kinetics. |

# DETAILED SYLLABUS - Paper III

## Course Code: RPSLSc103

| Unit | Course/ Unit Title | Credits/ Lectures |
|---|---|---|
| I | **Unit I: Protein and Lipids**<br><br>**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.<br>**Lipids:** structure, nomenclature, classification and properties of lipids, lipid assembly, model membranes, formation of liposomes and drug targeting. | 1/ 15L |
| II | **Unit II: Carbohydrates, Vitamins, Minerals**<br><br>**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.<br>**Vitamins:** Structure and biological roles of water soluble and lipid soluble vitamins, vitaminosis and deficiency.<br>**Minerals:** Structure and biological roles of bulk and trace elements. | 1/ 15L |
| III | **Unit III: Enzymology**<br><br>**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.<br>**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. | 1/ 15L |
| IV | **Unit IV: Photosynthesis, Mitochondrial & Chloroplast Electron Transport Chain**<br><br>**Photosynthesis & Chloroplast ETC:** Significance of photosynthesis. The structure, chemical composition, function and origin of Chloroplasts. Absorption of light, Photosynthesis pigments, Light energetics, Light harvesting complexes, Light and dark phase reaction mechanisms, Photorespiration. CO2 fixation by C3, C4 and CAM pathways. | 1/ 15L |

| | | |
|---|---|---|
| | **Mitochondrial ETC:** structure and function of mitochondrial ETC proteins and mechanism of oxidative phosphorylation, F0 F1 ATPase, theories of ATP synthesis. | |

**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 Km and Vmax 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<br>**At the end of the course students will be able to:** |
|---|---|
| **CO 1** | Review the scientific research process and the ethics involved. |
| **CO 2** | Distinguish between the different types of research methods. |
| **CO 3** | Formulate and 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** | Apply a suitable statistical test depending on the type of data, variables and samples. |
| **CO 6** | Understand the principles and working of various basic and advanced instruments essential for research as well as the patenting process and other intellectual property rights. |

# DETAILED SYLLABUS - Paper IV

**Course Code: RPSLSc104**

| Unit | Course/ Unit Title | Credits/ Lectures |
|---|---|---|
| I | **Unit I: Research Methodology and Scientific Writing**<br><br>**Introduction to research methodology:** Meaning, Objectives and Motivation in research;<br>**Types of research –** Descriptive, Analytical, Applied, Fundamental, Quantitative, Qualitative, Conceptual, Empirical and Other Types of Research;<br>**Research Approaches;** Research Methods vs. Methodology; Research and Scientific Method;<br>**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;<br>**Scientific misconduct:** Plagiarism, Fabrication, Authorship conflicts, Salami and imalas publication.<br>**Introduction to scientific writing:** Meaning of Scientific and non-scientific writing; Scientific Vocabulary and grammar. Synopsis, Dissertations, Thesis, Posters.<br>**Correspondence:** Formal letters, cover letters, drafting emails, replying to reviewers.<br>**Writing a Research paper:** Title, Abstract, Introduction, Review of literature, Methodology, Observations, Results, Discussions, Summary, Conclusion, and Bibliography (Referencing and citation styles). Supplementary data.<br>**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.<br>**Presentations:** Presenting numerical data - Graphical, Tabular, Animations, Slides etc. | **1/ 15L** |
| II | **Unit II: Biostatistics**<br><br>**Introduction:** Scope, application and uses of statistics, arithmetic mean, median, mode, standard deviation**.**<br>**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).<br>**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. | **1/ 15L** |

| | | |
|---|---|---|
| | **Population Statistics:** Population parameters and sample statistics, sampling techniques, simple random sampling, stratified random sampling, systematic sampling, standard error of mean. Estimation, point and interval, confidence interval for population, mean and proportion.<br>**Hypothesis testing:** type-1 and type-2 errors, levels of significance, one tailed and 2 tailed tests, application.<br>**Chi-test**: for independent attributes in rxc table, special case 2x2 table.<br>Students test for significance for correlation, coefficient r for P=0 (small sample tests). Fishers Z transformation coefficient for getting rp=0 in large samples, test of significance for r (p=0).<br>**Design of experiment:** principles and concepts of completely randomised design, randomized block design and Latin square design.<br>**Variance ratio F tests:** analysis of variance in one way classification.<br>**Non-parametric tests:** distribution free methods, sign test for method pairs, Willcoxon test for unpaired data, run test. | |
| **III** | **<u>Unit III: Instrumentation</u>**<br><br>**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.<br>**Microscopy:** Basic principles, instrumentation, sample preparation for optical, phase- contrast, interference, polarisation, inverted, fluorescence, confocal and electron microscopes and their applications.<br>**Centrifugation:** Principles and types, simple and differential, ultracentrifugation – preparative and analytical.<br>**Chromatography:** Principle, methodology and applications of chromatography using (paper, thin layer, column(gel filtration, ion exchange, affinity, gas, HPLC,FPLC etc).<br>**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).<br>**X-ray crystallography, Nuclear Magnetic Resonance (NMR) spectra, Magnetic Resonance Imaging (MRI – fMRI) lasers in biology and medicines.**<br>**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<br>**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. | **1/ 15L** |

| | | |
|---|---|---|
| **IV** | **Unit IV: IPR**<br>**IPR:** Introduction to IPR; Types of Intellectual property – Patents, Trademarks, 12 Copyrights and related rights; Traditional vs. Novelty; Importance of intellectual property rights in the modern global economic environment, Importance of intellectual property rights in India; IPR and its relevance in biology and environmental sciences; Case studies and agreements - Evolution of GATT and WTO and IPR provisions under TRIPS; Madrid agreement; Hague agreement; WIPO treaties; Budapest treaty; Indian Patent Act (1970).<br>**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. | **1/ 15L** |

**PRACTICALS: RPSLScP104 (2 credits)**

1. Preparation of Phosphate, Tris, and Citrate buffers of various molarity.
2. Determination of lambda max of $KMnO_4$, $CoCl_2$, 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. Analysing 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

**Online Examination:** (Deviation from the usual modality)
Owing to the pandemic situation prevailing in 2020 and continuing in 2021, the external examinations (Semester End) may be conducted online as per the instructions/circulars received from the University of Mumbai and Maharashtra State notifications from time to time. The conventional mode of external examination will commence again only after the declaration of normalcy by the Government authorities.

**Theory Examination Pattern:**

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

**A) Internal Assessment: 40 Marks**

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

**Rubrics chart for presentations**

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

## B) External Examination- 60 Marks

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

| Semester | Papers | Units covered | Question numbers and choice | Marks for each question | Total marks |
|---|---|---|---|---|---|
| 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. *Viva voce* | 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<br>**At the end of the course students will be able to:** |
|---|---|
| **CO 1** | Classify microorganisms and understand their growth curve patterns. |
| **CO 2** | Understand the various immunological processes that are involved in the body's defence system and the mechanisms used by the immune system to fight against viral, bacterial, parasitic infections. |
| **CO 3** | Appreciate how plants see the world through photoreceptors and their responses to abiotic and biotic stresses. |
| **CO 4** | Gain an insight on plant development and plant cell death. |
| **CO 5** | Choose an appropriate plant model system depending on a research objective. |
| **CO 6** | Appraise the different biochemical and signalling pathways for plant hormones. |

# DETAILED SYLLABUS - Paper I

**Course Code : RPSLSc201**

| Unit | Course/ Unit Title | Credits/ Lectures |
|---|---|---|
| I | **Unit I: Microbiology**<br>**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.<br>**Archaea:** Archaea as earliest life forms; halophiles, Methanogens<br>**Eukarya:** Algae, Fungi, Slime molds- General characteristics and types.<br>**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.<br>**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.<br>**Antibiotics:** General characteristics of antimicrobial drugs; Antibiotics: Classification, mode of action and resistance; Antifungal and antiviral drugs.<br>**Host Parasite Interaction:** Recognition, mechanism of microbial pathogenicity and establishment of disease by different pathogens like viruses, bacteria and parasites into animal hosts (one example each). Nosocomial infection; Emerging infectious diseases; alteration of host cell behavior by pathogens. | **1/ 15L** |
| II | **Unit II: Immunology:**<br>**Lymphatic system,** structure and function of spleen and lymph node.<br>**Major Histocompatibility Complex** I and II and their importance.<br>**B cells:** Development, generation of antibody diversity, activation somatic hypermutation and class switch. Primary and secondary immune modulation<br>**T cells:** Development, TCR diversity, selection and types of T cells and activation.<br>**The Complement and its regulation.**<br>**Immune response to infectious diseases:** Viral, Bacterial, Parasitic, AIDS.<br>**Congenital immunodeficiencies:** SCID.<br>**Autoimmune diseases -** Myasthenia gravis, Rheumatoid arthritis.<br>**Disease and application:** Monoclonal antibodies, SCFV, Chimeric antibodies, bispecific antibodies, phage display, Recombinant and polyvalent vaccines. | **1/ 16L** |
| III | **Unit III: Plant Physiology I**<br>**Plant model systems:** *Arabidopsis thaliana, Zea mays, Physcomitrella patens, Medicago truncatula, Populus trichocarpa, Oryza sativa.*<br>**Material transportation:** through xylem, phloem and plasmodesmata.<br>**Nitrogen metabolism:** Symbiotic nitrogen fixation, Ammonia and nitrate uptake and metabolism, amino acid biosynthesis.<br>**Plant Hormones:** Biosynthesis, signalling pathways and biological activity of Auxins, Cytokinins, Gibberellins, Ethylene, Abscissic acid, Salicylic acid, Jasmonates and Brassinosteroids. | **1/ 15L** |

| | | |
|---|---|---|
| | **Stress response:** Plant response to abiotic stress- Water, salt and temperature. Response and resistance to biotic stress (viral, fungal and insects): Host recognition and establishment of disease, overview of plant defence methods (anatomical, secondary metabolites, hypersensitive reactions, hormonal signals and the R - avr system). | |
| **IV** | **Unit IV: Plant physiology II**<br>**Plant Development:** Gametogenesis, germination of pollen and self-incompatibility, Double fertilization and seed formation (one typical example of each).<br>**Seed germination:** The hormonal and nutritional aspect of seed germination.<br>**Root and Shoot:** Development, organization of root and shoot apical meristems.<br>**Leaf development:** Development and phyllotaxy, stomatal movement.<br>**Flower development:** Flower induction, Floral organogenesis and the genes involved: Examples *Arabidopsis* and *Antirrhinum*.<br>**Sensory Photobiology:** Cryptochromes, phytochromes and phototropins. Photoperiodism and biological clocks. Role of Phytochromes in plant development.<br>**Programmed Cell Death and Senescence in plants:** Concept, effect on pigments in plants, environmental factors and hormonal factors. | **1/ 15L** |

**PRACTICALS: RPSLScP201 (2 credits)**

1. Diauxic growth curve of bacteria.
2. Antimicrobial activity by agar cup/ disc method.
3. Isolation of Protease producers from soil and estimation of the protease activity.
4. Sandwich ELISA. (Demonstration), HepElisa/ HCG Kit.
5. Radial immunodiffusion (Mancini test).
6. Comparison of proline content in normal and saline stressed plants.
7. Effect of salinity on seed viability.
8. Use of DNA Fluorochromes for studies on pollen grain and pollen tube nuclei.
9. Estimation of Indole Acetic Acid in plants.

**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<br>**At the end of the course students will be able to:** |
|---|---|
| **CO 1** | Compare the anatomy of various life processes like digestion, respiration, circulation and excretion across organisms. |
| **CO 2** | Examine the disorders arising from defects in physiological processes in humans. |
| **CO 3** | Correlate various developmental processes in an organism by understanding the important fundamental concepts of development like commitment, specifications, determination and differentiations with examples. |
| **CO 4** | Gain in-depth knowledge on the concepts of gametogenesis, fertilization and formation of germ layers during early development processes. |
| **CO 5** | Understand the basics of neuroanatomy and neurocellular mechanisms like electrical & chemical signaling and neurotransmission as well as the advanced functions of the nervous system such as the sensory systems, motor and movement control, behavior, emotions, learning, memory and pain |
| **CO 6** | Culture and maintain certain animal model organisms. |

# DETAILED SYLLABUS - Paper II

**Course Code : RPSLSc202**

| Unit | Course/ Unit Title | Credits/ Lectures |
|---|---|---|
| I | **Unit I: Animal Physiology:**<br>**Vascular system:** Blood corpuscles, haematopoiesis and formed elements, plasma function, blood volume, blood volume regulation, blood groups, haemoglobin, immunity, haemostasis.<br>**Cardiovascular System:** Comparative anatomy of heart structure, cardiac tissue, cardiac cycle, blood pressure, neural and chemical regulation.<br>**Respiratory system:** Comparative anatomy, transport and exchange of gases, neural and chemical regulation.<br>**Digestive system:** Comparative anatomy, human digestive system, Diet and BMR.<br>**Excretory system:** Comparative physiology, human excretory system, osmoregulation.<br>**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.<br>**Thermoregulation:** Comfort zone, body temperature – physical, chemical, neural regulation, acclimatization.<br>**Stress and adaptation** | **1/ 15L** |
| II | **Unit II: Developmental biology**<br>**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.<br>**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.<br>**Morphogenesis and organogenesis:** Dictyostelium - Cell aggregation, differentiation and culmination, Drosophila - axes and pattern formation, Vertebrates - eye lens induction and limb development; Differentiation of neurons; metamorphosis; environmental regulation of normal development; sex determination. | **1/ 15L** |
| III | **Unit III: Neurobiology**<br>**Overview: central nervous system (CNS) and peripheral nervous system (PNS)**- structure, organization and function<br>**Cellular perspective:** types of cells and function<br>**Impulse generation and conduction of nerve impulse** | **1/ 15L** |

| | | |
|---|---|---|
| | **Synaptic transmission:** Electrical and Chemical with examples of two neurotransmitters and their receptors; cAMP as messenger, Neuromuscular junctions – structure and function.<br>**Sensory systems:** Visual, Auditory, Chemosensory, Somatosensory<br>**Motor systems –** Overview of motor circuits and neural control.<br>**Behavior–** Reflexive behavior and homeostasis, Associative and non-associative memory. | |
| **IV** | **Unit IV: Model Systems**<br>**Fruit fly (*Drosophila melanogaster*) -** History and description of the invertebrate model. Culturing and maintenance. Research tools: Flybase, Mutant collection (Gene disruption project), Genome-wide application of genetic tools.<br>**Nematode worm (*Caenorhabditis elegans*) -** History and description of the model. Culturing and maintenance. Research tools – Wormbase, Wormatlas, Validation of target molecules in C. elegans (genome-wide RNAi, knockouts, compound libraries, HTPS and the MOA strategy)<br>**Western clawed frog (*Xenopus tropicalis*) -** Trans-NIH Xenopus Initiative, Xenbase<br>**Mouse (*Mus musculus*) -** Model organism for mammalian physiology, Types used for research, The Mouse Knockout & Mutation database.<br>**Zebrafish (*Danio rerio*) -** Model organism to study vertebrate physiology and development. Culturing and maintenance. Research tools- Genetic screens with morpholino's. Zebra fish assays. ZFIN database | **1/ 15L** |

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

# DETAILED SYLLABUS - Paper III

**Course Code : RPSLSc203**

| Unit | Course/ Unit Title | Credits/ Lectures |
|---|---|---|
| I | **Unit I: Gene and Epigenetics:**<br><br>**Structure of Gene:** Monocistronic and Polycistronic, Promoter, Operator, ORF, Terminator, Gene families, Pseudogenes, Split Gene.<br>**Other elements of Eukaryotic Genome:** Satellite DNA, Tandem repeat array, Transposons: LINE and SINE.<br>**Genomic Mutations:** Introduction, Deletions, Addition, Insertion, Inversions and Translocations.<br>**Chromatin Structure:** Histones, Non-Histones, Scaffolding proteins.<br>**Epigenetics:** Hypothesis, Imprinting, Mechanism (Methylation and Acetylation), Cancer epigenetics, Anticipation, Penetrance and Expressivity. | 1/ 15L |
| II | **Unit II: Gene Expression Regulation:**<br><br>**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.<br>**Regulation of Gene expression in Eukaryotes:** Regulatory strategies in Eukaryotes, Transcriptional Control by hormones, signalling factors and environmental factors, Role of transcription factors, enhancers, silencers, chromatin remodelling in regulation of gene expression, role of post-translational modifications of transcription factors, Regulation of processing, Regulation through RNA splicing, RNA degradation and RNA interference, Translational control. Diseases associated with defects in regulation. | 1/ 15L |
| III | **Unit III: Gene cloning**<br><br>**DNA Cloning:** Importance of DNA Cloning, Cloning methods - Principles of Cell-based DNA Cloning and cell independent DNA cloning, Cutting of DNA - Restriction & modification systems types and functions, Non R-M systems and Joining DNA methods - DNA Ligase mechanism, Linkers, Adaptors & Homopolymer tailing.<br>**Vectors:** Essential components of vectors and their significance, Plasmid vectors, Vectors based on the lambda Bacteriophage, Cosmids, M13 vectors, expression vectors, YACs and BACs. Genomic and cDNA libraries. Use of plant viruses as episomal expression vectors. Embryonic Stem cells for the production of genetically modified transgenic mice and knockout mice. | 1/ 15L |

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

**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/ ACTREC / any other institute.
5. Flow cytometry to distinguish between normal and cancer cells based on markers. (Demonstration)
6. Assessment of signaling pathways in the regulation of nitrate assimilation in plants/ bacteria.
7. Western Blotting to detect proteins of interest in cancer research (Demonstration).
8. Gene Cloning using Blue-white screening method (Demonstration).

**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<br>**At the end of the course students will be able to:** |
|---|---|
| **CO 1** | Understand the detailed mechanisms of various recombinant techniques & latest gene editing tools such as CRISPR/Cas. |
| **CO 2** | Acquire knowledge to use novel reporter systems, metabolic engineering aspects, in-silico modelling and Omics analysis. |
| **CO 3** | Recognise the importance of cloning any desired gene using suitable host and appropriate expression system. |
| **CO 4** | Compare and analyse various gene expression systems for variety of hosts including both prokaryotes and eukaryotes. |
| **CO 5** | Optimize various components and essential parameters involved in developing a gene expression system. |
| **CO 6** | Design an expression system for a suitable host organism to obtain recombinant protein product. |

# DETAILED SYLLABUS - Paper IV

**Course Code : RPSLSc204**

| Unit | Course/ Unit Title | Credits/ Lectures |
|---|---|---|
| I | **Unit I: Recombinant Techniques**<br>**Introduction to recombinant proteins.**<br>**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.<br>**Expression:** phage, cell, DNA, RNA, ribosome and IVC display,<br>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.<br>**Genome editing:** Homologus recombination, zinc finger nuclease, TALENS, CRISPR/Cas9, Modified nucleases – meganuclease.<br>**Application of RNAi in strain improvement:** use of siRNA, shRNA, miRNA, ribozymes and riboswitches to regulate and optimize gene expression.<br>**Metabolic Engineering:** Metabolic pathway analysis and modelling – approaches, Methods for metabolic engineering, Model organisms – *E. coli, B. subtilis*, *Saccharomyces*, plants and animals, Industrial applications.<br>**Systems Biology and Synthetic Biology for strain improvement:** Omics analysis, in silico modelling, development of improved strains. | **1/ 15L** |
| II | **Unit II: Microbial Expression Systems**<br>**Prokaryotic: *E. coli*:** Expression systems – pET, pBAD, λPL, prhaBAD systems, Expression of Foreign Genes in Bacteria – Problems, optimization of expression: host, transcriptional, translational, post translational compatibility, solubility and purification, transport and localization (use of Promoters, Ribosome Binding Site, Fusion Proteins, signal sequences, Tags and cleavage sites), Modification of gene – codon optimization, host strain modification Expression of Native Proteins, Detecting Expression of Foreign Genes.<br>**Gram Positive Bacteria:** *Bacillus subtilis, Lactobacilli, Streptomyces* – Expression systems, optimization of expression and applications. | **1/ 15L** |
| III | **Unit III: Engineering Lower eukaryotes I**<br>**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.<br>**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 | **1/ 15L** |

| | | |
|---|---|---|
| | expression, humanization of filamentous fungi (*Aspergillus*, etc.), applications - pharmaceutically important secondary metabolites, medicinal mushrooms (*Ganoderma*, etc.), polysaccharides from basidiomycetes for immunostimulatory and anticancer activity. | |
| **IV** | **Unit IV: Engineering Lower eukaryotes II**<br>**Yeasts:** Yeast Selectable Markers and Vector Systems, commercially used yeast strains (*S. cerevisiae* and *Pichia*) and their expression systems<br>**Heterologous Protein Production -** Design parameters: Source of DNA, Heterologous mRNA and protein levels and downstream applications, humanization of yeast for post translational compatibility.<br>**Uses:** Analysis of Genes, Genomes and Protein-Protein Interactions - YAC Technology, Constructing Gene Knockouts and Novel Reporter Systems, synthesis of commercially important compounds.<br>**Protozoa:** Advantages of protozoan expression systems, cultivation and applications of protozoan biotechnology. | **1/ 15L** |

**PRACTICALS: RPSLScP204 (2 credits)**

1. Transformation of *E. coli* and blue-white colony screening.
2. Preparation and regeneration of fungal protoplast.
3. Detection and estimation of gene copy number by real time PCR (demonstration).
4. Transformation of Yeast.
5. Slide culture of filamentous fungi with nuclei tracking using DAPI stain.
6. Replica Plating.
7. 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, 2ndedition, 1989: Maniatis, Fritsch and Sambrook
- Molecular Biology: A laboratory Manual, 4th edition, 2012: M. Green and J. Sambrook

# Assessment Modalities

**Online Examination:** (Deviation from the usual modality)
Owing to the pandemic situation prevailing in 2020 and continuing in 2021, the external examinations (Semester End) may be conducted online as per the instructions/circulars received from the University of Mumbai and Maharashtra State notifications from time to time. The conventional mode of external examination will commence again only after the declaration of normalcy by the Government authorities.

**Theory Examination Pattern:**

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

**A) Internal Assessment: 40 Marks**

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

**Rubrics chart for presentations**

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

## B) External Examination- 60 Marks

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

| Semester | Papers | Units covered | Question numbers and choice | Marks for each question | Total marks |
|---|---|---|---|---|---|
| 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. *Viva voce* | 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 | |

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

## 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<br>**At the end of the course students will be able to:** |
|---|---|
| **CO 1** | Appraise the technological aspects of plant tissue culture, animal tissue culture and aquaculture. |
| **CO 2** | Develop skills to prepare specialised media, sterilize and inoculate 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** | Distinguish between the various types of contamination that occurs during tissue culture and review the ways to control them. |
| **CO 6** | Design an ideal plant or animal tissue laboratory based on their respective requirements. |

# DETAILED SYLLABUS - Paper I

**Course Code : RPSLSc301**

| Unit | Course/ Unit Title | Credits/ Lectures |
|---|---|---|
| I | **Unit 1 - Plant Tissue Culture**<br><br>**Basics of plant tissue culture**: Laboratory set up and requirements, totipotency, macro and micro nutrients, media components and types.<br>**Micropropagation:** Steps involved, Culturing woody plants, Advantages, Somaclonal variation<br>**Culture:** Somatic embryogenesis and synthetic seed production. Callus culture and growth curves, Suspension cell culture. Protoplast culture, Somatic hybridization, Cybrids.<br>**Haploid Production:** Androgenesis, Gynogenesis, Applications<br>**Contamination**: Explant source, contamination types, disinfecting agents, control of microbial contaminants.<br>**Conservation:** Improvement, exploitation and conservation of genetic resources, Cryopreservation of genetic resources. | 1/ 15L |
| II | **Unit II: Transgenic Plants**<br><br>**Recombinant technology:** Plant transformation by *Agrobacterium tumfaciens* [including mechanism of T DNA transfer in wild type Agrobacterium], *A. rhizogenes* its plasmid, Biolistic: factors that influence transformation success,<br>**Applications of transgenic**: Overview, Recombinant proteins of pharmaceutical importance in plants including vaccine subunits, edible vaccines, from hairy root cultures.<br>**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;<br>Novel applications: change in lipid profile for industrial purpose, biodegradable plastics, novel horticultural traits [flower colour, variegation]. | 1/ 15L |
| III | **Unit III: Animal Tissue culture**<br><br>**Basics of animal tissue culture:** Methods of cell dissociation/separation and preparation of primary cell culture, characteristics of cells *in vitro*, cell culture growth parameters, detection, prevention and determination of contamination in tissue culture.<br>**Culture:** Primary cell culture, immortalized cell culture, stem cell culture and transformed cell culture. Specialized cells: bone marrow, skin cell culture, myogenesis, erythrogenesis and-chondrogenesis- *in vitro*,<br>**Preservation:** Cryopreservation of tissues and cell lines.<br>**Analysis and Production:** cell synchronization, cell transformation *in vitro*, Mass cultivation- cytodex and bio fermenters. | 1/ 15L |

| | | |
|---|---|---|
| | **Applications:** Stem cells & therapeutic cloning, Tissue engineering and 3D printing. | |
| **IV** | **<u>Unit IV: Aquaculture</u>**<br><br>**Aqua culture technology**: definition, history and scope, constraints and recent development, criteria for selection of species, aquafarm engineering.<br>**Pisciculture**: cultivable fish species, seed production technology of carps, carp culture, mono and poly culture.<br>**Prawn culture**: cultivable prawn species, spawning techniques, culture methods in India.<br>**Pearl oyster culture**: pearl producing species, pearl culture technology, composition of pearl quality and prospects.<br>**Seaweed culture**: economically important species culture and post-harvest technology. | **1/ 15L** |

**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<br>**At the end of the course students will be able to:** |
|---|---|
| **CO 1** | Understand the fundamental concepts of fermentation techniques, methods used for product recovery, the associated product economics and explain the importance of effluent treatment. |
| **CO 2** | Differentiate between various types of fermenters and design the components and optimize various essential parameters required in a fermenter. |
| **CO 3** | Derive microbial growth kinetics for fermentation processes and optimize the culture conditions to scale up the production. |
| **CO 4** | Identify and analyse techniques of isolation, preservation of microbial cultures and various fermentation media used for optimum production. |
| **CO 5** | Classify plant secondary metabolites and understand the industrial production of some important metabolites. |
| **CO 6** | Enlist the scope of enzymes in various commercial industrial productions of food, nutraceuticals, and other essentials. |

# DETAILED SYLLABUS - Paper II

**Course Code: RPSLSc302**

| Unit | Course/ Unit Title | Credits/ Lectures |
|---|---|---|
| I | **Unit I: Upstream and Downstream Processes**<br><br>**Fermenter design:** Components of the fermenter, sterilization, aeration and agitation.<br>**Types of Fermenters:** batch, continuous, air lift, fluidized bed, stirred tank.<br>**Isolation and Screening of microorganisms:** Isolation of microorganisms from various sources, Preservation, Primary and Secondary Screening of microorganisms.<br>**Fermentation Media:** Definition, Criteria, Various components, Types: crude and synthetic, sterilization, rheology of various components of media.<br>**Microbial growth**: General parameters, growth kinetics for various fermentation and types of stock culture, scaling up of culture for fermentation.<br>**Product recovery:** Product: internal, external, cell disruption methods: physical, chemical and biological, precipitation, filtration, centrifugation, extraction and purification, drying.<br>**Product Economics:** Microbial culture, Fermentation: Upstream and Downstream processes, recovery process, product processing.<br>**Effluent Treatment:** Need, Traditional methods disposal and disadvantage, physical, chemical and biological methods. | 1/ 15L |
| II | **Unit II: Fermentation process I**<br><br>**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.<br>**Commercial Fermentations: Cheese:** Culture, Fermentation process, Applications.<br>**Alcohol:** Wine, Commercial Ethanol (by-product fusel oils): Culture, Process and Applications.<br>**Acids:** Lactic acid industrial production and applications.<br>**Carbohydrate:** High fructose corn syrup.<br>**Flavour/fragrance production** with example. | 1/ 15L |
| III | **Unit III: Fermentation Process II**<br><br>**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.<br>**Examples of secondary metabolite production (**industrial scale**)**: [shikonin, taxol (biosynthesis and bioreactor production) capsaicin/ berberine].<br>**From microbes:** Polymers [dextrans, xanthan gums, alginate], antibiotics [peptide, lantibiotics, aminoglycosides, beta lactam], cyclosporins, biosurfactants. | 1/ 15L |

| | | |
|---|---|---|
| **IV** | **<u>Unit IV: Enzymes in Industry</u>**<br><br>**Biotransformations:** Classification and characteristics of enzymes – OTHLIL, applications of enzymes: (chiral synthesis of enantiomerically pure compounds, resolution of isomers). Examples of biotransformations.<br>**Industries:** Textile Processing, Leather Processing, Paper & Pulp Processing, Detergents and laundry.<br>**Food biotechnology:** Fruit and vegetable processing: juices, nectars, purees; syrup and glucose isomerases, enzymatic synthesis of aspartame.<br>**Other industrial uses**: Vinegar, Baking, Cocoa fermentation, Olive oil production, fish processing industries.<br>**Nutraceuticals:** Probiotics: lycopene, isoflavonoids, glucosamine, phytosterol.<br>**Feed Biotechnology**: lignocelluloses into feed using cellulases, silage.<br>**Bio preservation:** chemical preservatives and their safety concerns, LAB Bacteriocins. Types of bacteriocins, mode of action, applications and regulations. | **1/ 15L** |

**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<br>**At the end of the course students will be able to:** |
|---|---|
| **CO 1** | Classify the biological databases that are used in bioinformatics and select and use the appropriate biological database according to the query. |
| **CO 2** | Construct phylogenetic trees manually as well as computationally after understanding the concepts, terminologies, types and properties of phylogenetic trees and the various methods of building it. |
| **CO 3** | Understand the concept of multiple or pairwise sequence alignment and select the appropriate software to carry out the alignment. |
| **CO 4** | Audit biotechnology/pharmaceutical industries as per ISO standards as well as the GMP and GLP guidelines by knowing the requirements and procedure of these certifications which may provide a basis for a future career in quality assurance or quality management. |
| **CO 5** | Write a successful business plan and investment proposal, understand how to set up their own businesses and take inspiration from successful Indian bio-entrepreneurs. |
| **CO 6** | Debate on various topics involving bioethics and understand the relevance of bioethics in regulating exciting developments in biology and medicine. |

# DETAILED SYLLABUS - Paper III

**Course Code : RPSLSc303**

| Unit | Course/ Unit Title | Credits/ Lectures |
|---|---|---|
| I | **Unit I: Bioinformatics**<br><br>**Introduction to Bioinformatics**: Definition and History of Bioinformatics, Different Omics and its application and Current status.<br>**Computers:** Operating systems, Internet and its components, Internet sources for Bioinformatics, Flat file.<br>**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.<br>**Biological databases**: Classification, Primary DNA Databases, Primary and Secondary Protein Databases, Composite Structure Databases, UniProt, Protein Data Bank (PDB), Metabolism Database (KEGG). | 1/ 15L |
| II | **Unit II: Alignment problem and solutions**<br><br>**Multiple Sequence Alignment (MSA)**: Definition, Objective, Consensus, Methods for MSA: Heuristic approach, Dynamic programming approach and their combinations.<br>**Pairwise Alignment**: Introduction, PAM Matrix, BLOSUM Matrix, The Dot Plot, Global alignment, Local alignment, FASTA and BLAST. Statistics: P and E value.<br>**Phylogenetic Analysis**: Molecular-Phylogenetics, Phylogenetic-trees, Terminology of tree-reconstruction, rooted and un-rooted trees, gene vs species trees and their properties, Methods: UPGMA, Neighbour-Joining Method, Maximum Parsimony. | 1/ 15L |
| III | **Unit III: ISO, GMP, GLP**<br><br>**Introduction:** Overview of standards in ISO9000 Family<br>**Key principles**: Key principles of ISO 9000- Quality Management System<br>**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<br>**Application:** Sector specific Application of ISO 9001- Quality Management System adapted by various industries<br>**Introduction to GMP** (Good Manufacturing Practices) and GLP (good Laboratory Practices) in Pharmaceutical Industries.<br>**Overview:** GMPs and enforcement by the U.S. Food Drug Administration (US FDA) under Title 21 CFR. Documentation requirement related to GMP and GLP.<br>**Case studies** for SOP preparation and CAPA (Corrective action Preventive Action). | 1/ 15L |

| | | |
|---|---|---|
| **IV** | **Unit IV: Bioethics and Entrepreneurship**<br><br>**Bioethics**: Definition – moral, values, ethics and ethics in biology; Role and importance of ethics in biology; Legal and regulatory issues; Bioethics in healthcare, agriculture, modern biology, biotechnology, animal welfare & right / animals in research, wildlife conservation and management, commercialism in scientific research.<br>**Entrepreneurship:**<br>**Biotechnology industry** - Emerging trends in biotechnology industry, organizational structure.<br>**Setting up a Biotechnology industry** - Writing a business plan, Funding and investment sources (Government funding, angel investors, venture capitalists, strategic investors, crowdfunding, self-funding, bank loans, IPO), Government schemes for women. Exit strategy.<br>**Licensing** - Motivations for licencing, scope, types and fees.<br>**Technology transfer** – University technology transfer and issues involved.<br>Government policies (National biotechnology development strategy, Maharashtra biotechnology policy, National policy on skill development and entrepreneurship).<br>**Business ethics and CSR**.<br>**Bioentrepreneurs** – Bio-entrepreneurship in Rural and Urban India, examples of Indian Bioentrepreneurs. | **1/ 15L** |

**Practicals for RPSLScP303: (2 credits)**

1. Retrieving protein / nucleotide sequence information from databases – UniProt, NCBI.
2. Pathway analysis using KEGG and BioCyc.
3. Performing BLASTn, BLASTp, tBLASTn and PSI-BLAST using NCBI.
4. Multiple sequence alignment using MEGA.
5. Phylogenetic tree construction using MEGA.
6. Primer designing for a gene in the human genome using NCBI.
7. Restriction mapping using NEB cutter.

**References:**


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

**PAPER 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<br>**At the end of the course students will be able to:** |
|---|---|
| **CO 1** | Follow and develop the strict norms of Good Laboratory Practices in their respective laboratories. |
| **CO 2** | Design and perform experiments, document results, perform statistical analyses and write their observations and conclusions independently. |
| **CO 3** | Organise their time and resources, and be resourceful in the absence of certain instruments or reagents. |
| **CO 4** | Learn to troubleshoot failed experiments and gain the ability to interpret both positive and negative results. |
| **CO 5** | Work independently as well as in pairs or groups by adopting the culture of inclusivity. |
| **CO 6** | Present their work in the form of oral or poster presentations at the national or international conferences or publish their work in research journals approved by the new UGC CARE list if deemed suitable by their research guides. |

# Assessment Modalities

**Online Examination:** (Deviation from the usual modality)
Owing to the pandemic situation prevailing in 2020 and continuing in 2021, the external examinations (Semester End) may be conducted online as per the instructions/circulars received from the University of Mumbai and Maharashtra State notifications from time to time. The conventional mode of external examination will commence again only after the declaration of normalcy by the Government authorities.

**Theory Examination Pattern:**

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

**A) Internal Assessment: 40 Marks**

- Assignments include presentation on any research paper / conference/ guest lecture / design of website or brochure / quizzes / subjective tests / preparation of business plan/ creative writing / mock audit / meme making assignment / video assignment / survey / debate pertaining to syllabus topics chosen or allotted.
- Students are informed at least a month in advance about the portions for topics of the assignments or presentations via emails or on google classroom and marking scheme in the form of rubrics are known to them and hard copies depicting the names of students with topics and rubrics are maintained as proofs with their signatures with date.
- Below is an example of the rubrics.

**Rubrics chart for presentations**

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

## B) External Examination- 60 Marks

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

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

### Practical Examination Pattern: 50 Marks

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

| Semester | Papers | Question | Total marks |
|---|---|---|---|
| III | 1, 2 and 3 | Q1. Major experiment | 30 |
| | | Q2. Identification | 10 |
| | | Q3. *Viva voce* | 5 |
| | | Q4. Journal | 5 |
| **Total marks** | | | **50** |

**Paper IV Examination Pattern: 150 Marks**

| Semester | Paper | Question | Total marks |
|---|---|---|---|
| III | 4 | Q1. Project work thesis | 60 |
| | | Q2. Project work presentation | 40 |
| | | Q3. *Viva voce* on project | 50 |
| **Total marks** | | | **150** |

# 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 (150 marks) | Theory | 60 | |
| | Internals | 40 | |
| | Practicals | 50 | |
| IV (150 marks) | Project thesis and presentation | 100 | |
| | Project viva | 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<br>**At the end of the course students will be able to:** |
|---|---|
| **CO 1** | Understand the principles, classification, production and examples of gene therapy, antisense therapy and protein therapeutics. |
| **CO 2** | Distinguish between gene therapy, antisense therapy and protein therapeutics and select the appropriate therapy for the treatment of a certain disease. |
| **CO 3** | Recall the important new concepts in engineering of vaccines and peptibodies and their applications for various diseases. |
| **CO 4** | Evaluate disease models used for developing new therapeutics, and computational models for rational drug design. |
| **CO 5** | Assess the pharmacogenomics of various illnesses like cancer syndromes, neuropsychotic and cardiovascular disorders. |
| **CO 6** | Investigate the steps involved in drug designing right from identification of the API in activity guided drug development to its metabolism and action. |

# DETAILED SYLLABUS - Paper I

**Course Code : RPSLSc401**

| Unit | Course/ Unit Title | Credits/ Lectures |
|---|---|---|
| I | **Unit I: Therapeutics I**<br><br>**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.<br>**Antisense therapy:** Introduction, strategies. oligodeoxyribonucleotide, catalytic antisense RNA, triple - helix forming oligonucleotides (TFOs), production, and limitations, first generation antisense drugs, second generation antisense drugs.<br>Applications: cancer therapy, viral diseases, gene function analysis and in agriculture.<br>**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. | 1/ 15L |
| II | **Unit II: Therapeutics II**<br><br>**Genetic Engineering of Vaccines**: Identification and Cloning of Antigens with VaccinePotential - DNA/Oligonucleotide Hybridization, Hybrid Selection and Cell-free Translation, Expression cloning and Genomic Sequencing, Analysis of Vaccine Antigens - B-cell Epitopes and T-cell Epitopes. Generation of Subunit Vaccines, Improvement and Generation of New Live Attenuated Vaccines - *Pseudorabies* Virus, *Vibrio* and *Poliovirus*, Recombinant Live Vectors - *Vaccinia* Virus, Recombinant BCG Vaccines, Attenuated *Salmonella* Strains, Poliovirus Chimaeras, Cross-species Vaccination, 'Live- dead' Vaccines, Other Virus Vectors and Recombinant *E. coli* Strains, DNA, RNA and peptide Vaccines, Anti-idiotypes, Enhancing Immunogenicity and modifying Immune Responses - Adjuvants, Carriers and Vehicles, Carriers, Mucosal Immunity, Modulation of Cytokine Profile, Modulation by Antigen Targeting and Modulation of Signaling.<br>**Peptibodies**: Definition, peptide-Fc fusion, advantages over monoclonal antibodies, production in *E. coli* using recombinant DNA technology, production, and mechanism of action, applications – pain, ovarian cancer and immune thrombocytopenic purpura, limitations.<br>**Peptidomimetics**: Definition, design, features, analysis and application.<br>**Biosimilars**: Definition, design, features, analysis and application. | 1/ 15L |

| | | |
|---|---|---|
| **III** | **Unit III: Activity Guided Drug Development**<br><br>**Plant collection and Extract preparations**: Methods of Plant collection, solvent extraction (cold, hot, critical fluid extraction etc), screening of medicinal properties;<br>**Natural products**: methods of identification (Qualitative and Quantitative), isolation and purification (Chromatography), Characterization;<br>**Bio efficacy studies**: *In vitro* testing- Antimicrobial, Antidiabetic, Antioxidant, Anti Inflammatory and Anti larvicidal activities.<br>**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. | **1/ 15L** |
| **IV** | **Unit IV: Pharmacogenomics and Drug design**<br><br>**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.<br>**Pharmacogenomics:** Cancer syndromes, neuropsychotic disorders, Alzheimer's disease, mental retardation, cardiovascular diseases, smoking and alcoholism, Eugenics and epigenetics of above disorders,<br>Genetic influences on drug targets involved in pharmacodynamics, long QT syndromes, emerging technologies. | **1/ 15L** |

**PRACTICALS: RPSLScP401 (2 credits)**

1. Residual DNA analysis of recombinant therapeutic protein.
2. Multiplex PCR
3. Pedigree analysis (disease/disorder/trait)
4. Separation and visualisation of a plant extract by HPTLC.
5. Bioautography for antimicrobial / antioxidant activity.
6. Anti-inflammatory/Anti-diabetic assay of a plant extract.

**References:**


1. Molecular Biology and Biotechnology, 4th edition (2002) by J. M. Walker and R. Rapley
2. Biotechnology by Rehm & Reed
3. Biotechnology, An Introduction (2008) by S. Ignacimuthu, S. J.
4. Biotechnology, Concepts and Applications (2009) by R. R. Vittal and R. Bhat
5. Biotechnology, Principles and Applications (2007) by S. C. Rastogi
6. Medical Biotechnology, Himalaya Publishing House, Mumbai, (2008) by Jogdand S. N.,
7. Medical Biotechnology, Churchill Livingstone, Elsevier (2009) by Judit Pongracz, Mary Keen
8. Medical Biotechnology, Oxford University Press (2010) by Pratibha Nallari& V. Venugopal Rao,
9. Therapeutic peptides and proteins by A. K. Banga

10. Plant Bioactives and Drug Discovery: Principles, Practice, and Perspectives 1st Edition Valdir Cechinel-Filho(Author), Wiley Publication.
11. Drug Discovery from Plants By Angela A. Salim, Young-Won Chin, A. Douglas Kinghorn (Springer publication)
12. Bioassay Methods in Natural Product Research and Drug Development By Lars Bohlin, Jan G. Bruhn (Springer Publication).

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

# DETAILED SYLLABUS - Paper II

**Course Code: RPSLSc402**

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

| | | |
|---|---|---|
| **IV** | **Unit IV: Diagnostics and Forensics**<br><br>**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;<br>F**orensics:** Crime-Scene Investigation and Evidence Collection, the Study of Hair, Pollen and Spore Examination, Fingerprints, Forensic Anthropology. Death: Meaning, Manner, Mechanism, Cause, and Time. DNA Fingerprinting: Markers MLP, SLP, mitochondrial DNA, Y chromosome analysis, X chromosome analysis. Blood and Blood Spatter, Drug Identification and Toxicology SNPs. | **1/ 15L** |

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

# DETAILED SYLLABUS - Paper III

**Course Code: RPSLSc403**

| Unit | Course/ Unit Title | Credits/ Lectures |
|---|---|---|
| I | **Unit I: Biological Controls and Biopesticides**<br><br>**Chemical Pesticides:** Spectrum of chemical pesticides for control of biotic stress: uses, advantages and disadvantages.<br>**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.<br>**Biopesticides from Plants**: Neem and pyrethrins, mode of action on insect pests, Bio-control against fungal diseases of plants.<br>**Biological Controls:** Viral/ fungal/ bacterial parasites for control of insect pests, life cycle, symptoms and mode of action. | 1/ 15L |
| II | **Unit II: Nitrogen Fixation and Biofertilizers**<br><br>**Nitrogen fixation:** Molecular genetics: *nif* genes and regulation of *nif* gene expression, *fix* genes.<br>**Biofertilizer**: definition, methods of manufacture, application to soil and seed.<br>**Aquaponics: fish culture and plant culture using this water.**<br>**Mycorrhiza:** Types, importance to plant health (nutrient uptake, resistance to stress, microbial symbiosis), importance of network analysis, role in ecosystem (Plant to plant interaction).<br>**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. | 1/ 15L |
| III | **Unit III: Bioremediation**<br><br>**Solid management:** Types, need, unit processes, laws and regulations.<br>**Composting:** physical and chemical factors, microbiology, health risk from pathogens, odour sources.<br>**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.<br>**Bioremediation:** using natural, genetically engineered bacterial systems and plants with examples. **Heaps. Dumps and biomineralization** | 1/ 15L |

| | | |
|---|---|---|
| **IV** | **Unit IV: Phytoremediation and phytomining**<br><br>**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,<br>Restoration of soil, water and air quality citing suitable examples**.**<br>**Phytomining:** Factors influencing metal uptake by plants in soil, Implementing phytomining, extraction of valuable minerals/ metals from low grade ore/soils.<br>**Biotechnology in gold mining/ extraction.** | **1/ 15L** |

**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<br>**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 software 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** | Solve basic calculus problems as well as examples in biological scenarios through the use of mathematics which is required to understand ecological modelling, growth curves, population genetics, epidemic modelling, enzyme kinetics, analysing drug efficacies as well as cancer treatment modelling to name a few. |

# DETAILED SYLLABUS - Paper IV

**Course Code: RPSLSc404**

| Unit | Course/ Unit Title | Credits/ Lectures |
|---|---|---|
| I | **Unit I: Protein Trafficking and Targeting**<br><br>Intracellular and membrane protein trafficking and targeting; Secretory pathways in prokaryotes and eukaryotes;<br><br>Co-translational transport (protease protection assay) - Endocytic pathways; Signal sequences; secretory proteins and membrane protein synthesis and docking.<br>N-glycosylation in the ER and Golgi.<br><br>Quality control - UPR, ERAD and proteosomal degradation.<br>Post-translational transport - Targeting of mitochondrial, chloroplast, peroxisomal and nuclear proteins;<br><br>Vesicle biogenesis and ER to Golgi transport; ER translocation of polypeptides (soluble and transmembrane); ER chaperons; SNAPs and SNAREs; Methods of studying Protein Transport; Disorders of protein transport. | 1/ 15L |
| II | **Unit II: Protein folding and Biomolecular interactions**<br><br>**Thermodynamics**: The laws of thermodynamics, enthalpy, entropy and free energy concepts and their relevance to biological systems.<br><br>**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.<br><br>**Biomolecular Interactions and diseases**:<br>Structural and functional aspects of proteins and DNA: Relationships between structure and function and their role in human diseases; Protein-DNA interactions; Protein-RNA interactions; Protein-Protein interactions; Protein aggregation; Non-Enzymatic glycosylation (Protein- sugar interactions); Methods to study these interactions. | 1/ 15L |

| | | |
|---|---|---|
| **III** | **Unit III: Advanced Bioinformatics**<br><br>**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.<br>**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.<br>Application in drug designing: Drug targets, Lead Identification and Modification, Computer-Aided Drug Design. | **1/ 15L** |
| **IV** | **Unit IV: Biomathematics**<br><br>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. | **1/ 15L** |

**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 Autodock Vina.
5. Motif Finding- MEME and TomTom
6. Secondary Structure Prediction: Porter 5.0
7. Tertiary Structure: ExPasy in SWISS

**References:**

1. Molecular cell biology by Lodish ($5^{th}$ Edition).
2. Biochemistry by Stryer.
3. Biochemistry by Harper.
4. Introduction to Bioinformatics- Attwood, Parry-Smith and Phukan.
5. Bioinformatics: Sequence and Genome Analysis- David W. Mount.
6. Bioinformatics and Functional Genomics- Jonathan Pevsner.
7. Fundamentals of Bioinformatics: Harisha S.
8. Bioinformatics and Molecular Evolution: Higgs & Attwood.
9. Bioinformatics: Harshwardhan Pal.

# Assessment Modalities

**Online Examination:** (Deviation from the usual modality)
Owing to the pandemic situation prevailing in 2020 and continuing in 2021, the external examinations (Semester End) may be conducted online as per the instructions/circulars received from the University of Mumbai and Maharashtra State notifications from time to time. The conventional mode of external examination will commence again only after the declaration of normalcy by the Government authorities.

**Theory Examination Pattern:**

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

**A) Internal Assessment: 40 Marks**

- Assignments include presentation on any research paper / conference/ guest lecture / design of website or brochure / quizzes / subjective tests / preparation of business plan/ creative writing / mock audit / meme making assignment / video assignment / survey / debate pertaining to syllabus topics chosen or allotted.
- Students are informed at least a month in advance about the portions for topics of the assignments or presentations via emails or on google classroom and marking scheme in the form of rubrics are known to them and hard copies depicting the names of students with topics and rubrics are maintained as proofs with their signatures with date.
- Below is an example of the rubrics.

**Rubrics chart for presentations**

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

## B) External Examination- 60 Marks

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

| Semester | Papers | Units covered | Question numbers and choice | Marks for each question | Total marks |
|---|---|---|---|---|---|
| IV | I, II, III, 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. *Viva voce* | 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 | |

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