
# St Aloysius College (Autonomous)

# Mangaluru

**Re-accredited by NAAC "A" Grade**

# Course structure and syllabus of

# M.Sc.

# BIOCHEMISTRY

## CHOICE BASED CREDIT SYSTEM

**(2021-22 Batch Onwards)**

ಸಂತ ಅಲೋಶಿಯಸ್ ಕಾಲೇಜು (ಸ್ವಾಯತ್ತ)
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Re-accredited by NAAC with 'A' Grade with CGPA 3.62/4
Recognised by UGC as "College with Potential for Excellence"
Conferred "College with "STAR STATUS" by DBT, Government of India.
Centre for Research Capacity Building under UGC-STRIDE

Date: 12-08-2021

# NOTIFICATION

Sub: Syllabus of **M.Sc. Biochemistry** under Choice Based Credit System.

Ref: 1. Decision of the Academic Council meeting held on 19-06-2021vide Agenda No: 9 (2021-22)

2. Office Notification dated 12-08-2021

Pursuant to the above, the Syllabus of **M.Sc. Biochemistry** under Choice Based Credit System which was approved by the Academic Council at its meeting held on 19-06-2021 is hereby notified for implementation with effect from the academic year **2021-22.**

**PRINCIPAL**

ST. ALOYSIUS COLLEGE MANGALURU 575 003 (AUTONOMOUS)

**REGISTRAR**

To:

1. The Chairman/Dean/HOD.
2. The Registrar Office
3. Library
4. PG Office

## M.Sc. in the subject Biochemistry

### 1. Introduction

The framework for the postgraduate program in Biochemistry is intended to provide an academic base that caters to the need of the students to gain comprehensive understanding of Biochemistry and its ever-evolving nature of applications. The curriculum design is aimed at attaining snd maintaining standard of achievement with respect to knowledge, skills and the technical know-how to apply the knowledge gained to progress discovery, invention and application in the field.

The curriculum also aims at fostering scientific attitudes such as rational reasoning, critical thinking, problem solving and values such as ethics, social and environmental concern. The curriculum finally aims at excellenceon par with the standard Higher Education Institutions.

### 2. Learning Outcomes based approach to Curriculum planning

The learning outcome-based approach, has been designed to identify the minimum learning outcome from a student after completing each course. This entire outcome is substantiated by the practical components.

The scheme of syllabus, instruction, examination, evaluation etc., has been prepared with the following objectives in mind.

- To empower students to understand the concepts in the field of Biochemistry
- To facilitate students to acquire theoretical and practical skills for a successful career in academia, industry and research.
- To encourage innovation and creativity among students and to foster the spirit of research and entrepreneurship to contribute positively to the progress of the society

### 3. Nature and extent of the Post Graduate programme in Biochemistry

The two-year full time M.Sc. programme in Biochemistry endeavours to provide students with excellent training in Biochemistry highlighting on providing a strong foundation of basic concepts as well as rapidly evolving advancement in the field. The theoretical knowledge, will be substantiated by providing hands on experience in the basic and advanced techniques of Biochemistry and linked subjects through practical training in masters' laboratory in both the years. Avaluable feature of the programme is the augmentation of Practical Skills in Research through a Research project that will allow students to get hands-on-experience in tools and methods used in in research. This is followed by dissertation/ project thesis carried out on a research topic under the supervision of a mentor. The idea is to familiarize students to the different aspects of

research including research methodology, scientific reading, critical review of the scientific literature, organizational capability, analytical ability, experimental design and execution and research ethics.

**4. Post Graduate Attributes**

It is expected that at the end of the programme, each student aquries knowledge, skills, attitudes and values that will make them independent and confident in in their chosen career and playing a constructive role as a responsible citizen in the society. The students are expected to be able to apply biochemical principles to understand various complex processes in life sciences and provide solutions to combat various human diseases. The characteristics attributes of postgraduates inBiochemistry Program include:

i. **Disciplinary Knowledge and Skills -** Capable of demonstrating
   a. comprehensive knowledge and understanding of basic and advanced concepts, theoretical principlesand research findings in Biochemistry and its different subfields like Enzymology, bioenergetics, toxicology, immunology, Physiology, genetics, molecular biology, genetic engineering, microbiology, bioinformatics etc.
   b. ability to use modern instrumentation and laboratory techniques to design and perform experiments in Biochemistry and related subjects.

ii. **Communication Skills**: Ability to speak and write clearly in English and to listen to and follow scientific viewpoints and debate.

iii. **Critical Thinking and scientific reasoning**: Ability to make logical conclusions based on evidence AND logically apply methods to evaluate hypotheses.

iv. **Problem Solving**: Ability to conduct an experiment, including stating a hypothesis raising appropriate questions, identifying and controlling variables,and interpreting by applying lateral thinking and analytical skills.

v. **Digital Literacy*:*** Competency in using e-resources and software for analysis of data. Ability to use bioinformatic tools to locate, retrieve, evaluate and apply biological information

vi. **Teamwork and Time Management**: Ability to participate constructively in class room discussions, to contribute to group work and meet deadlines.

vii. **Moral and Ethical awareness:** Ability to evaluate one's own ethical values, and to be aware of ethical to refrain from unethical practices.

viii. **Life-long Learning**: Ability to retain and build on generic and critical thinking skills by consistently reading, reviewing and researching about technological advancement through self-directed learning.

## 5. Qualification descriptors for PG program in Biochemistry

The key qualification descriptor for Post -Graduate Biochemistry shall be coherent knowledge of concepts, experimentation, communication as well as critical thinking and ethical awareness. Each postgraduate in Biochemistry should be able to •

- Demonstrate

  (i) a systematic, extensive and coherent knowledge and understanding of the academic field of study as a whole and its applications, and links to related disciplinary areas/subjects of study.

  (ii) procedural knowledge that creates different types of professionals related to the subject area of Biochemistry, including research and development, teaching and government and public service;
- Demonstrate skills in identifying information needs, collection of relevant quantitative and/or qualitative data from around the world, analysis and interpretation of data using methodologies as appropriate to the subject of Biochemistry and related subjects
- Use knowledge, understanding and skills in Biochemistry for critical assessment of a wide range of ideas and complex problems and issues relating to the various subfields of Biochemistry
- Communicate ideas, opinions and values—both scientific themes and values oflife, in order to extend the knowledge of the subject from the classroom/laboratory to industry and society.
- Demonstrate the skill to share the results of academic and disciplinary learning through various forms of communication such as reports, dissertations, essays, seminars, publications, etc, on different platforms of communication.

## 5. M.Sc. Biochemistry Programme: Learning outcomes

A two-year program will lead to the award of a M.Sc. degree in Biochemistry. Students will be offered advanced level theory and practical courses in subjects like biomolecules, physiology and nutrition, biochemical techniques, organic and physical chemistry, cell biochemistry, biotechnology, immunology, genetic engineering, biostatistics, research methodology, ethics, bioinformatics, metabolism and other related concepts that will help students gain comprehensive knowledge in the field. Other feature of the programme is seminars (in all four semesters) that students are required to present in open forum for collective evaluation by the departmental faculty members aimed at fostering skills like habit of scientific reading, analytical ability, leadership organizational capability, independent thinking, basic professional skills, generic and technical skills, ethical values,

integrity and honesty. Additionally, during the programme particular emphasis will be given to attaining research experience; this includes work by students in research laboratories to carry out projects under the supervision of faculty members. The department strives to achieve the following

**Programme outcomes:**

PO1: Comprehensive knowledge of Biochemistry with inter-disciplinary perspective of other branches of life sciences

PO2:Competence to use modern biochemical and molecular techniques to perform experiments to test scientific hypotheses, analyse data, trouble -shoot and draw conclusions from the experimental data in labs.

PO3: Ability to write research thesis, and present and defend their findings to scientific audiences at regional or national levels.

PO4: Capacity to work independently, while still promoting teamwork and collaboration skills.

**Program Specific Outcomes:**

A student upon completion of this post-graduate programme in Biochemistry should be able to demonstrate:

PSO 1: **Fundamental understanding of Biochemistry**, structure and function of biological molecule, mechanisms of biological processes and bioenergetics.

PSO 2: Competence to understand theories and methods that can be used **to *link*Biochemistry to related subjects** such as biotechnology, molecular biology, genetics, pharmacology, immunology, genetic engineering and Biostatistics and informatics

PSO 3: Ability to make quantitative measurements of parameters that are routinely encountered in **practical/ experimental biochemistry** and apply a range of techniques that are commonly used in biomoleculeanalysis.

PSO 4: Ability to a**nalyse and interpret biochemical data** acquired from the experimental procedures and demonstrates analytical and problem-solving skills with regard to biochemical principles of life processes.

PSO 5: Competence in **research and innovation** in Biochemistry and in related field of specialization and the ability to critically review scientific literature for development of new theories and testable hypothesis.

PSO 6: **Basic professional skills** pertaining to biochemical analysis, and the ability to use these skills in specific areas such as technology development, industrial production and skills that are relevant to biochemistry-related jobs and employment opportunities

PSO 7: Skill of **articulation of ideas, scientific writing**, authentic reporting, scientific conversation and writing, capacity for decision making with regard to scientific progress, personal development and career choice.

PSO 8: **Entrepreneurial and social competence,** the ability to plan and manage projects in order to achieve objectives

PSO 9: **Leadership and organizational skills**, ability to work independently, while still promoting team work and collaboration skills.

PSO 10: Ability to **translate knowledge of biochemistry to address environment issues** including, waste disposal management, safety and security issues, nature conservation, sustainability development etc.

PSO 11: Relevant **generic and technical skills** including communication skills effective interaction with others, listening, speaking, observational skills, utilization of e-resources and ICT.

**PSO 12:** Professional behavior withrespect to attribute like**ethical values**, **integrity, honesty,** and sense of responsibility.

## Programme Learning Outcomes

## Hard Core courses

| S. No. | | PH. 511.1 | PH. 512.1 | PH. 513.1P | PH. 511.2 | PH. 512.2 | PH. 513.2P | PH. 511.3 | PH. 512.3 | PH. 513.3P | PH. 514.3P | PH. 511.4 | PH. 512.4 | PH. 513.4P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Fundamental understanding of Biochemistry | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 2. | *Link* Biochemistry to related subjects | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 3. | Practical/ procedural biochemistry | | | ✓ | | | ✓ | | | ✓ | ✓ | | | ✓ |
| 4. | Analyse and interpret biochemical data | | ✓ | ✓ | | | ✓ | | | ✓ | ✓ | | | ✓ |
| 5. | Research and innovation | ✓ | ✓ | | ✓ | ✓ | | ✓ | ✓ | | | ✓ | ✓ | ✓ |
| 6. | Articulation of ideas, scientific writing | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 7. | Basic professional skills | | | ✓ | | | ✓ | | | ✓ | ✓ | | | ✓ |
| 8. | Entrepreneurial and social competence | | | ✓ | | | ✓ | | | ✓ | ✓ | | | ✓ |
| 9. | Leadership and organizational skills | | | ✓ | | | ✓ | | | ✓ | ✓ | | | ✓ |
| 10. | Translate knowledge of biochemistry to address environment issues | | | ✓ | | | ✓ | | ✓ | ✓ | ✓ | | | ✓ |
| 11. | Generic and technical skills- communication and ICT skills. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 12. | Attributes likeethical values, integrity, honesty, and sense of responsibility. | | | ✓ | | | ✓ | | | ✓ | ✓ | | | ✓ |

**Programme Learning Outcomes**
**Soft Core courses**

| S. No. | | PS. 514.1 | PS. 515.1 | PS. 516.1 | PS. 517.1P | PS. 518.1 P | PS. 514.2 | PS. 515.2 | PS. 516.2 | PS. 517.2P | PS. 518.2P | PS. 515.3 | PS. 516.3 | PS. 514.4 | PS. 515.4 | PS. 516.4 | PS. 517.4P | PS. 518.4P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Fundamental understanding of Biochemistry | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 2. | *Link* Biochemistry to related subjects | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| 3. | practical/ procedural biochemistry | | | | ✓ | ✓ | | | | ✓ | ✓ | | | | | | ✓ | ✓ |
| 4. | analyse and interpret biochemical data | ✓ | | | ✓ | ✓ | | | | ✓ | ✓ | | | | | | ✓ | ✓ |
| 5. | Research and innovation | | | | ✓ | ✓ | | | | ✓ | ✓ | | | | | | ✓ | ✓ |
| 6. | Articulation of ideas, scientific writing | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | | |
| 7. | Basic professional skills | | | | ✓ | ✓ | | | | ✓ | ✓ | | | | | | ✓ | ✓ |
| 8. | Entrepreneurial and social competence | | | | | | ✓ | ✓ | | ✓ | | | | | | | ✓ | |
| 9. | Leadership and organizational skills | | | | ✓ | ✓ | | | | ✓ | ✓ | | | | | | ✓ | ✓ |
| 10. | Translate knowledge of biochemistry to address environment issues | | | | ✓ | ✓ | | | | ✓ | ✓ | | | | | | ✓ | ✓ |
| 11. | Generic and technical skills- communication and ICT skills. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| 12. | Attributes likeethical values, integrity, honesty, and sense of responsibility. | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

**Programme Learning Outcomes**

**Open elective courses**

| S. No. | | P0. 519.2 | PO. 517.3 |
|---|---|---|---|
| 1. | Fundamental understanding of Biochemistry | ✓ | ✓ |
| 2. | *Link*Biochemistry to related subjects | ✓ | ✓ |
| 3. | Practical/ procedural biochemistry | | |
| 4. | analyse and interpret biochemical data | ✓ | ✓ |
| 5. | Research and innovation | ✓ | ✓ |
| 6. | Articulation of ideas, scientific writing | ✓ | ✓ |
| 7. | Basic professional skills | ✓ | ✓ |
| 8. | Entrepreneurial and social competence | ✓ | ✓ |
| 9. | Leadership and organizational skills | ✓ | ✓ |
| 10. | Translate knowledge of biochemistry to address environment issues | ✓ | ✓ |
| 11. | Generic and technical skills- communication and ICT skills. | ✓ | ✓ |
| 12. | Attributes likeethical values, integrity, honesty, and sense of responsibility. | ✓ | ✓ |

**6. Programme Structure:**

The Master's programme is a two-year course divided into four semesters. A student is required to complete 92 credits for the completion of course and the award of degree.

**First Year**: Semester I Semester II

**Second Year**: Semester III Semester IV

The Choice Based Credit System (CBCS) comprises courses in the form of Hard Core, Soft Core for Biochemistry Students and Open Elective course for students other than Biochemistry. Following shall be the minimum and maximum courses per semester.

The credit pattern is Lecture (L); Tutorial (T); Practical (P); (L:T:P) Pattern.

**Lecture:** One hour session of theory class per week in a semester is 1 credit.

**Practical:**Two-hour session of tutorial or practical per week in a semester is 1 credit.

**One semester period** is 16 weeks of teaching and learning.

**Duration of semester** is 20 weeks that includes semester end examinations.

**Credit Pattern of courses:**

| **Semester** | **Hard core credits** | | **Soft core credits** | | **Open elective credits (O)** | **Total Credits** |
|---|---|---|---|---|---|---|
| | Theory | Practical/ Project | Theory | Practical/ Project | | |
| **I** | 9 | 4 | 6 | 3 | - | 22 |
| **II** | 9 | 4 | 6 | 3 | 3 | 25 |
| **III** | 9 | 8 | 3 | - | 3 | 23 |
| **IV** | 8 | 5 | 6 | 3 | - | 22 |
| **Total** | 35 | 21 | 24 | 9 | 6 | 92 |

**7. CRITERIA FOR ADMISSION**

Candidates who have passed the three-year B.Sc. degree examination of Mangalore University or any other University considered as equivalent thereto with **Biochemistry/Chemistry** as optional/major/special subjects with minimum of 45% (40% for SC/ST/Category-I candidates) marks are eligible for the programme provided they have studied **Biology** as major / optional / minor Special/subsidiary subject either at B.Sc. or at PUC/ Higher Secondary level. Candidates who have passed Bachelor Degree examination in Biomedical Science are also eligible.

## 8. Pedagogies employed in the M.Sc. programme

**Class room teaching**: include the chalk and black board method, use of power point presentation, inquiry-based learning and group discussions.

**E-learning**: includes online components, which can be an assessed part of the degree. This includes online lectures, online tests, and assignments.

**Laboratory and practical learning:** students will perform the experiments in the laboratory, troubleshoot, interpret and present the results

**Presentation**: Student seminar/research paper presentation in each semester.

**Research**: includes literature review in the form of Dissertation. And project work on a small research problem.

**Talks**: includes Webinars, seminars and Invited talks from eminent scientists, Professors and entrepreneurs

**Co-curricular activities**

**Wall journal:** Students maintain a wall journal where all important research findings, job opportunities, creativity etc are displayed

**Biochemistry association:** All the students are members of Biochemistry association- a platform for show casing their talents- curricular and co-curricular.

**Rural exposure camp:** Students have to undergo compulsory **rural exposure camp** in order to sensitize them to the needs of the society.

| M.Sc. Biochemistry | | | | | | | |
|---|---|---|---|---|---|---|---|
| **I Semester (2+1 Hard core and 2+1 soft core paper)** | | | | | | | |
| **Code** | **Papers** | **Instruction hours/ Week** | **Duration of Exam (hours)** | **Marks** | | **Total** | **Credits** |
| | | | | **IA** | **End Semester** | | |
| PH 511.1 | Biomolecules | 5 | 3 | 30 | 70 | 100 | 5 |
| PH 512.1 | Biochemical Techniques | 4 | 3 | 30 | 70 | 100 | 4 |
| PH 513.1P | Bioquantitation | 8 | 4 | 30 | 70 | 100 | 4 |
| PS 514.1 | Organic and Physical Biochemistry | 3 | 3 | 30 | 70 | 100 | 3 |
| PS 515.1 | Physiology and Nutrition | 3 | 3 | 30 | 70 | 100 | 3 |
| PS 516.1 | General microbiology | | | | | | |
| PS 517.1P | Analytical Techniques | 8 | 4 | 30 | 70 | 100 | 3 |
| PS 518.1P | Experimental microbiology | | | | | | |
| | **Total** | | | | | **600** | **22** |
| **II Semester (2+1 Hard core and 2+1 Soft core papers and 1 open elective paper)** | | | | | | | |
| PH 511.2 | Enzymology | 5 | 3 | 30 | 70 | 100 | 5 |
| PH 512.2 | Metabolism | 4 | 3 | 30 | 70 | 100 | 4 |
| PH 513.2P | Practical Enzymology | 8 | 4 | 30 | 70 | 100 | 4 |
| PS 514.2 | Research Methodology and Ethics | 3 | 3 | 30 | 70 | 100 | 3 |
| PS 515.2 | Biotechnology | 3 | 3 | 30 | 70 | 100 | 3 |
| PS 516.2 | Neurobiochemistry | | | | | | |
| PS 517.2P | Practical Biotechnology | 8 | 4 | 30 | 70 | 100 | 3 |
| PS 518.2P | Experimental Neurobiochemistry | | | | | | |
| PO 519.2 | Biochemistry of Diseases | 3 | 3 | 30 | 70 | 100 | 3 |
| | **Total** | | | | | **700** | **25** |

| M.Sc. Biochemistry | | | | | | | |
|---|---|---|---|---|---|---|---|
| **III Semester (2+2 Hard core and 1 Soft core papers and open elective 1 paper** | | | | | | | |
| **Code** | **Papers** | **Instruction hours/ Week** | **Duration of Exam (hours)** | **Marks** | | **Total** | **Credits** |
| | | | | **IA** | **End Semester** | | |
| PH 511.3 | Molecular Biology | 5 | 3 | 30 | 70 | 100 | 5 |
| PH 512.3 | Nitrogen Metabolism & Plant Biochemistry | 4 | 3 | 30 | 70 | 100 | 4 |
| PH 513.3P | Metabolism & clinical Biochemistry | 8 | 3 | 30 | 70 | 100 | 4 |
| PH 514.3P | Cell & Molecular Biology | 8 | 3 | 30 | 70 | 100 | 4 |
| PS 515.3 | Cellular Biochemistry | 3 | 3 | 30 | 70 | 100 | 3 |
| PS 516.3 | Clinical Biochemistry | | | | | | |
| PO 517.3 | Evolution and Ecology | 3 | 3 | 30 | 70 | 100 | 3 |
| | **Total** | | | | | **600** | **23** |
| **IV Semester (2+1 Hard core and 2+1 Soft core papers)** | | | | | | | |
| PH 511.4 | Immunology | 4 | 3 | 30 | 70 | 100 | **4** |
| PH 512.4 | Genetics | 4 | 3 | 30 | 70 | 100 | **4** |
| PH 513.4P | Project | 10 | 3 | 30 | 70 | 100 | **5** |
| PS 514.4 | Genetic Engineering & Bioinformatics | 3 | 3 | 30 | 70 | 100 | **3** |
| PS 515.4 | Clinical Toxicology | 3 | 3 | 30 | 70 | 100 | **3** |
| PS 516.4 | Food Biochemistry | | | | | | |
| PS 517.4P | Methods in Genetic Engineering & Bioinformatics | 8 | 3 | 30 | 70 | 100 | **3** |
| PS 518.4P | Experiments in food science | | | | | | |
| | | | | | | **600** | **22** |
| | **Grand Total** | | | | | **2500** | **92** |

## PH 511.1. BIOMOLECULES

**Total No. of Lectures: 56 hours** **Total marks: 70**

**No. of Lectures/week: 5** **Credits: 5**

**Course Objective**

*The objective is to enable the students to obtain detailed knowledge about the dynamic biomolecules that sustain life, providing basic concepts of structure and biological function The first unit elaborates on amino acids, peptides & proteins, second unit on 3D structure of proteins, the third unit discusses the classification and biological functions of carbohydrates, the fourth unit discusses lipids, while the fifth unit deals with the study of nucleic acids.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

CO 1: Explain the basic aspects of amino acids, peptides, organization of protein structure, carbohydrates, lipids and nucleic acids

CO 2: Describe the structure - function relationship of proteins and nucleic acids.

CO 3: State the role of various biomolecules in health and disease.

CO 4: Interpret the different structures of biomolecules and their implications on different disease states.

CO 5: Explain classification and properties of various biomolecules.

**Unit - I** **14 L**

**Amino acids and Peptides:**

Amino acids-Common Structural features, structure of standard amino acids as zwitter ions in aqueous solution, physical and chemical properties. Structures and occurrence of nonstandard and nonprotein amino acids, separation of amino acids, essential amino acids.

Structure of Peptide bond. Naturally occurring peptides - Structure and functions. Physical and Chemical properties. Chemical synthesis of Peptides –protection and deprotection of N-terminal, C- terminal and functional groups in the side chain, formation of peptide bond, condensing agents, strategy of chemical synthesis, Merrifield solid phase peptide synthesis.

**Proteins:**

Classification based on solubility in common buffers, shape, composition and function with suitable examples. Hierarchical description of Protein structure- Primary structure-chemical structure, Secondary structure – α-helix, $3_{10}$-helix, β-pleated sheets, β-turns and loops, Ramachandran's plot.

**Unit – II** **12L**

**Tertiary and quaternary structure of Proteins-** Forces stabilizing the tertiary and quaternary structure. Super secondary structures. Determination of amino acid sequence of a polypeptide chain-specific chemical and enzymatic cleavage of polypeptide chain and separation of peptides.

Three - Dimensional structures of globular (Myoglobin, Haemoglobin, Sickle cell haemoglobin - structure and functional relationship) and Fibrous proteins (Collagen,Keratin) and determination of subunit composition. Denaturation - Melting temperature, effect of salts, Chaotropic agents. Protein folding – Anfinsen's studies on ribonuclease. Thermodynamics of protein folding:molten globule model, Chemical modification of proteins.

**Unit- III** **8L**

**Carbohydrates:** Classification, Monosaccharides- classification with structures. Sugar derivatives - alcohols, acids, amino sugars, deoxysugars, glycosides Oligosaccharides-structure and linkages in lactose, maltose, and sucrose, raffinose series oligosaccharides, Polysaccharides- Homo and heteropolysaccharides, glycosaminoglycans, bacterial cell wall peptidoglycans. Glycoconjugates- structural features and biological functions of Proteoglycans and Glycoproteins (O-linked, N-linked and GPI-linked). Isolation and analysis of carbohydrates.

**Unit – IV** **8L**

**Lipids:**

Classification and structure of fatty acids, Isomerism, unsaturated Fatty acids, their significance. Classification of lipids. Fats and waxes. Chemistry and biological functions of phospholipids, glycolipids, eicosanoids, terpenes (isoprene rule) & steroids. Physio - chemical properties and Characterization of fats, oils and waxes. Isolation and analysis of lipids.

**Unit– V** **14L**

**Nucleotides and Nucleic acids:**

Nomenclature, Structure and properties of pyrimidine & purine bases, nucleosides & nucleotides of nucleic acids, Conformation of nucleotides, Nucleic acids- classes and their functions. Physico-chemical properties DNA & RNA- base composition & primary structure of single-stranded DNA & RNA, Shorthand notation of polynucleotide structure. Chargaff's rules, Structure & function of DNA-Watson-Crick &Hoogsteen base pairing, different forms of DNA, Unusual structures of DNA-supercoiled, bend, cruciform, triplex and G-DNA, DNA-RNA hybrids, Forces stabilizing structure of DNA. Denaturation - hypochromic and hyperchromic effect; melting temperature. Renaturation kinetics-effect of salts & complexity. Hybridization and its significance.

Chemical differences between DNA and RNA and its significance, Different class of RNAs - mRNA, rRNA, tRNA and snRNA. Primary, secondary and tertiary structure of tRNA. Chemical method for synthesis of oligonucleotide chain-triester method (Phosphoramidite method). Determination of primary structure (sequencing) of DNA using Maxam-Gilbert method & limitations. Sanger and Coulson's method, advantages & drawbacks.

**References:**


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## PH 512.1 BIOCHEMICAL TECHNIQUES

**Total No. of Lectures: 56 hours** **Total marks: 70**

**No. of Lectures/week: 4** **Credits: 4**

**Course Objective:**

*This paper deals with the principle, construction, and application of various techniques used by Biochemists to understand the life processes.*

*The first unit deals with basic techniques for cell fractionation, isolation and chromatographic separation of biomolecules. The second and third unit emphasizes on the physical methods of determining size, shape and structure of biomolecules. The fourth unit introduces the various spectroscopic techniques.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

CO 1: List the basic instruments used in analytical biochemistry and state their applications.

CO 2: Explain the principles and applications of important techniques used in isolation, purification and characterization of various biomolecules.

CO 3: Interpret the various molecular spectrum obtained from different spectral techniques.

CO 4: Explain preparation and analysis of different samples biological samples to be subjected to various analytical techniques.

CO 5: Gain technical competency in different advanced techniques with a comprehensive understanding of their principle, instrumentation and applications.

**Unit-I** **14L**

Preliminary Techniques in Biochemistry – Clarification techniques- Cell Fractionation Techniques – mechanical and non-mechanical methods of Cell disruption, Concentration - Ultra filtration, precipitation by organic solvents and Salting out, lyophilization; Dialysis; Chromatographic Techniques – Principle and Applications of Paper, TLC, column chromatography based on Adsorption, Ion exchange, Gel filtration, Affinity &Chromatofocusing; HPLC- principle, instrumentation, different columns and detectors, their application and FPLC. Gas Liquid Chromatography- instrumentation, detectors.

**Unit-II** **16L**

**Physical methods of determining size, shape and structure of molecules**

Electrophoretic Techniques for Biomolecules separation– native Polyacrylamide gel electrophoresis, SDS-PAGE, Agarose gel Electrophoresis, Isoelectric focusing, pulsed field electrophoresis, High voltage electrophoresis, Capillary Electrophoresis, Isotachophoresis. Visualization by staining. Centrifugation: Ultra Centrifugation – Preparative and analytical ultra centrifuge –Instrumentation, principle and application, Svedberg's constant, Sedimentation velocity, Sedimentation equilibrium &Schlieren Optics, Magnetic Resonance spectroscopy– NMR: nature of NMR absorption, chemical shift, spin-spin splitting,$^{13}C$ &$^{1}H$ NMR spectra for suitable organic molecules, interpretation of spectra, its application for biomolecules. ESR – Principle and Applications.

**Unit-III** **12L**

**Methods to determine biopolymers structure**- Mass spectrometry- theory, instrumentation, ionization, fragmentation, m/e, typical bar graph of mass spectrum, interpretation mass spectra, time of flight, MALDI, GC-MS, and ESI. X-ray Crystallography – Protein crystals, Bragg's law, unit cell, Isomorphous replacement, Fiber pattern of DNA Microscopy-Principles and application of light microscopy, application of different stains, phase contrast, fluorescence, Confocal microscopy, scanning and transmission electron microscopy, Cytophotometry and flow cytometry, FACS

**Unit-IV** **14L**

**Spectroscopic Techniques** – Beer-Lambert's Law, application and Limitation, light absorption and its transmittance, determination and application of Extinction Coefficient, UV-Visible Spectroscopic techniques- Instrumentation and applications of Turbidometry, Flame photometry, Vibration Spectra – IR- Principle, applications & characteristic IR absorptions of some functional groups and Raman spectroscopy– Principle and applications, use in elucidation of the protein structure. Principle, instrumentation and applications of Atomic spectroscopy, fluorescence and emission spectroscopy: uses.Polarized Light – plane and circularly polarized light, CD/ORD spectroscopy & its applications.

**References:**

1. Principles and techniques of biochemistry and molecular biology. Wilson, K. and J. M. Walker (2005). Cambridge ; New York, Cambridge University Press.
2. Principles and techniques of biochemistry and molecular biology. Wilson, K. and J. M. Walker (2009). Cambridge, UK New York, Cambridge University Press.
3. An introduction to practical biochemistry. Plummer, D. T. (1978). London ; New York, McGraw-Hill.
4. An introduction to practical biochemistry. Plummer, D. T. (1987). London ; New York, McGraw-Hill.
5. Biophysical chemistry-Principles and techniques- Upadhay, Upadhyay and Nath(2010) Himalaya publishing house
6. Biophysical Chemistry: Principles, Techniques, and Applications : Solutions Manual, Marshall, A. G. (1978). John Wiley & Sons Canada, Limited.
7. Biophysics. Pattabhi, V. and N. Gautham (2002). Boston Delhi, Kluwer Academic ;Narosa Publications.
8. Biophysical chemistry. Cooper, A. and Royal Society of Chemistry (Great Britain) (2011). Cambridge, RSC Pub.
9. The tools of biochemistry. Cooper, T. G. (1977). New York London, Wiley.
10. Physical chemistry for the biological sciences. Hammes, G. G. and S. Hammes-Schiffer(2015) Wiley New York
11. Molecular and cellular biophysics. Jackson, M. B. (2006). Cambridge, Cambridge University Press.
12. Proteomics: a Cold Spring Harbor Laboratory course manual. Link, A. J., J. LaBaer, et al. (2009).Cold Spring Harbor, N.Y., Cold Spring Harbor Laboratory Press.
13. Proteomics: from protein sequence to function. Pennington, S. R. and M. J. Dunn (2001). Oxford, BIOS.
14. Protein purification techniques: a practical approach. Roe, S. (2001). Oxford ; New York, Oxford University Press.
15. Physical biochemistry: principles and applications. Sheehan, D. (2009). Chichester, UK ; Hoboken, NJ, Wiley-Blackwell.

## PH 513.1P BIOQUANTITATION

**Total Marks: 70**

**Practical: 8hr/wk** **Credits : 4**

**Course objective**

*The objective is to enable students to develop skills in the practical components, learn good laboratory practices, preparations of various solutions and estimation of biomolecules using different methods.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

CO 1: Learn good laboratory practices and be able to prepare basics of solutions
CO 2: Perform and explain the principle of colorimetric analysis of various biomolecules.
CO 3: Interpret and present scientific and technical information derived from laboratory experiments.

1. Quantitative estimation of reducing sugars by DNS Method
2. Estimation of total sugar by Phenol sulphuric acid/Anthrone method
3. Quantitative estimation of Proteins by UV absorption by Lowry's method
4. Quantitative estimation of Proteins by UV absorption by Biuret method
5. Quantitative estimation of DNA by Diphenylamine method
6. Quantitative estimation of RNA by Orcinol method
7. Quantitative estimation of ascorbic acid
8. Quantitative estimation of total phenol by using Folin-Ciocalteu reagent.
9. Qualitative analysis of some common food adulterants in milk, turmeric, tea powder, honey, Oil, Ghee and grains
10. Quantitative analysis: Proximate analysis
    a. Determination of moisture content
    b. Determination of oil content by Soxhlet method
    c. Determination of ash content of food sample
    d. Determination of mineral content- Fe+2, $Ca^{+2}$
    e. Determination of Crude protein nitrogen by Kjeldahl method
    f. Quantification of non-protein nitrogen
11. Analysis of anti-nutritional factors
    a. Soybean trypsin inhibitor
    b. Determination of rancidity in edible oil
12. Lipid Analysis
    a. Iodine number
    b. saponification value
    c. acid value
    d. peroxide value.

## PS 514.1 ORGANIC AND PHYSICAL BIOCHEMISTRY

**Total No. of Lectures: 42 hours** **Total marks: 70**
**No. of Lectures/week: 3** **Credits: 3**

**Course objective:**

*The objective is to enable the students to understand the structure and reaction mechanisms of organic molecules and water; application of thermodynamics and radioisotopes in biochemistry.*

*The first unit discusses the basics of bonding and stereochemistry and its importance in understanding biochemical reactions. Second unit explains the physical properties of water and thermodynamic law and its application in biology. Third unit elaborates on Radioisotopes in Biology.*

**Course Learning Outcomes:** At the completion of this course, students will be able to

CO 1: Explain the basic concepts of different types of chemical bonds, that can be useful to understand the chemical nature of biomolecules.

CO 2: Describe the thermodynamic parameters and their variations in homeostasis of cells and its biomolecules and their interaction with water.

CO 3: Acquire knowledge about preparation of radioisotopes, their applications in studying the cellular metabolic processes.

CO 4: Display skills in problem solving, critical thinking and analytical reasoning as applied to problems in organic and physical chemistry

**Unit-I** **20L**

**Bioorganic chemistry**

Atoms and atomic orbitals, molecular orbital (hydrogen molecule), Covalent bond; coordinate bond; $sp^n$hybridization.

Isomerism and Stereochemistry: - Structural isomerism, Geometric isomerism, optical isomerism: optical activity, chirality, enantiomers, diastereomers, meso-compound, Fischer projection, threo-erythro notation, DL, RS configuration (in sugars and amino acids).

Cyclic structures of monosaccharides; Haworth projection, boat and chair forms, anomers and mutarotation, glycosides.

**Types of organic reactions-** substitution, addition, elimination, rearrangement, condensation and polymerization.

**Mechanism of substitution in the benzene ring-** ortho, para and meta directed groups. The concept of resonance with reference to benzene derivatives, Direct influence of substituents- electronic interpretation.

**Free radicals in biological systems**- Oxygen as a free radical in the autooxidation of fats. Antioxidants (free radical inhibitors in the cell such as vitamins-A, E, C, Glutathione and Se).

**Heterocyclic Compounds** – Numbering of the ring, properties and Biological occurrence of furan, pyran, indole, thiazole, pteridine, isoalloxazine, pyrrole, quinone, purine & pyridine rings.

**Unit-II** **12L**

**Thermodynamics in Chemistry and biochemistry** – open, closed and isolated system, Laws of thermodynamics- I law, II law and III law, applications of thermodynamic laws in understanding energies in living system. Chemical potential and equilibrium constant.

Oxidation and redox reactions- characteristics, half reactions, spontaneous & non-spontaneous redox reaction.

**Water-**Physical properties & structure of water, hydrogen bonding and hydrophobic interactions. ionization of water, pH scale, Acids and bases, Henderson- Hasselbalch equation, buffers, buffer capacity, ionic strength, buffer solutions & their action,

**Unit-III** **10L**

**Radioisotopes in Biology** – Nature of radioactivity, properties of α, β, γ-rays, Types of isotopes used in Biochemistry, Units of radioactivity, Nature of radiation sources, Techniques used to measure radioactivity– GM counter and scintillation counter, solid and liquid scintillation, autoradiography. isotopes commonly used in biochemical studies- $^{3}H$, $^{14}C$, $^{32}P$, $^{131}I$, $^{35}S$, their biological application-*invivo* and *invitro*labeling techniques, double labeling, quenching, internal standard, channel ratio, external standard ratio, emulsion counting, concept of half life, decay constant, Specific activity. Synthesis of Isotopicallylabeled glucose and ATP (α, γ). Biological hazards of radiation and safety measures in handling radioisotopes

**References:**


1. Roberts, J. D., &Caserio, M. C. (1977). *Basic principles of organic chemistry*. WA Benjamin, Inc...
2. Bahl, B. S., &Bahl, A. (2017). *A textbook of organic chemistry*. S. Chand Publishing..
3. Finar, I. L. (1956). *Organic Chemistry, Volume 2: Stereochemistry And The Chemistry Natural Products, 5/E*. Pearson Education India..
4. Mosher, M. (1992). Organic Chemistry. (Morrison, Robert Thornton; Boyd, Robert Neilson)..
5. Eliel, E. L., & Wilen, S. H. (1994). *Stereochemistry of organic compounds*. John Wiley & Sons..
6. Campbell, I. D., &Dwek, R. A. (1984). *Biological spectroscopy*. Benjamin/Cummings Pub. Co...
7. Upadhyay, A., Upadhyay, K., & Nath, N. (2003). Biophysical Chemistry Principles & Techniques Handbook..

## PS 515.1 PHYSIOLOGY & NUTRITION

**Total No. of Lectures: 42 hours** **Total marks: 70**

**No. of Lectures/week: 3** **Credits: 3**

**Course objective**

*The objective is to offer knowledge about the physiology and function of different organs of the human body and the nutritional aspects essential for the maintenance of health.*

*The first unit deals with circulatory, respiratory, hepatobiliary, excretory and gastrointestinal system. The second unit deals with the endocrine and reproductive system. The third unit elaborates on macro and micronutrients.*

**Course Learning Outcomes:** At the completion of this course, students will be able to

CO 1: Explain the functions of important physiological systems including the cardio-respiratory, reproductive renal, and metabolic systems

CO 2: Explain the integration of the different organs in maintaining homeostasis

CO 3: Discuss diseases, disorders, and conditions that result from a homeostatic imbalance

CO 4: State the role of nutrients, caloric requirements and the deficiency disorders

**Unit-I** **20L**

Introduction to Human body, Organs and organ systems, Homeostasis

**Blood:** Composition of Blood, Plasma; composition and function, Blood cells; Haematopoiesis, RBC-erythropoiesis, life cycle and function, WBC- types and functions, platelets and their functions. Blood coagulation (haemostasis and thrombosis), anticoagulants, and fibrinolysis. Buffer systems of plasma, total and differential blood count.

Body fluids-CSF and Lymph- composition & functions.

**Cardiac Physiology**: Cardiac conduction system, Cardiac cycle, Cardiac Output, Blood pressure, ECG.

**Respiratory System** – Lungs structure and functions. Gas exchange, oxygen binding by haemoglobin, factors affecting oxygenation.

**Excretory System;** Kidney– Ultra structure of the nephron, mechanism of glomerular filtration and formation of urine. Role of kidney in acid-base balance. Kidney function test.

**Hepatobiliary System** – Anatomy of the liver, blood supply, cells – hepatocytes, endothelial cells & Kupffer cells. Secretory and excretory function-formation of bile, composition, Secretion of bile and enterohepatic circulation, Liver function test.

Gall bladder and its functions

**Pancreas-** Anatomy, its exocrine and endocrine activities. Target tissues & biological functions of insulin & glucagon.

**Gastrointestinal System**– Physiology and biochemistry of digestion and absorption of food. Mechanism of HCl production in the stomach, Gastro-intestinal hormones and their role.

**Unit-II** **10L**

**Endocrine system-** Endocrine organs in man, The target cell concept, major groups of hormones- lipophilic and hydrophilic hormones -their general features.

Structure, anatomy and control of hypothalamus - hormones produced & their role.

Hypothalamic- hypophysiotropic hormones- biological role. The hypothalamo-Pituitary axes with major feedback loops.

Adenohypophysial- tropic hormones, lipotropin, endorphins & enkephalins-their biological action. Neurohypophysial.hormones- their biological action. ANF (atrial natri uretic factor).

Thyroid gland, thymus & adrenal gland- hormones & their biological functons. renal hormones: Functions; Renin-angiotensin system. Pineal gland-melatonin, its role in circadian rhythm & aging.

Hormones of Gonads: Anatomy of testes and ovaries, their endocrine functions, Hormone synthesis, storage, secretion and regulation, their physiological and biochemical aspects - hormonal control of puberty, hormonal regulation of menstrual cycle, Oral contraceptives.

**NUTRITION**

**Unit-III** **12L**

**Nutrition –** Introduction about Concepts of macro and micro nutrients, Energy value of food methods of determining energy value of foods- Bomb calorimeter, Benedict's Oxy Calorimeter, Direct Calorimeter, physiological fuel value, daily requirement of energy, Basal metabolic rate (BMR), factors affecting BMR, specific dynamic action of foods.

**Carbohydrates -** dietary sources, dietary fibre, **Proteins** – Evaluation of nutritive value of dietary protein: PER, BV, essential amino acids, nutritional classification of proteins, supplementary value of proteins, protein calorie malnutrition: Kwashiorkar and Marasmus.

**Fats** – Sources, invisible fat, essential fatty acids, PUFA, Recommended daily allowances,

**Vitamins** – Fat soluble(A, D, E, K) and water soluble (vitamins B Complex and vitamin C): structure, provitamins, anti-vitamins, dietary sources, RDA, function and deficiency symptoms of vitamins.

**Minerals** – Macrominerals (Calcium, phosphorous, sodium, potassium, chloride), Microminerals (iron, iodine, copper, zinc, selenium):sources, requirements, functions and deficiency symptoms

**Special Diet**-FAD, Atkins diet, lactating and pregnant women diet.

**References:**


1. Murray, R. K., Granner, D. K., Mayes, P. A., & Rodwell, V. W. (2014). *Harper's illustrated biochemistry*. Mcgraw-hill.
2. Devlin, T. M. (Ed.). (2011). Textbook of biochemistry: with clinical correlations.
3. Burtis, C. A. (Ed.). (1999). *Tietz textbook of clinical chemistry*. Saunders.
4. Vasudevan, D. M., Sreekumari, S., & Vaidyanathan, K. (2016). *Textbook of biochemistry for medical students*. JP Medical Ltd.
5. Ganong, W. F. (1995). *Review of medical physiology*. Mcgraw-hill.
6. Guyton, A., & Hall, J. (2006). Textbook of medical physiology, 11th. edition
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9. Jenkins, G., & Tortora, G. J. (2016). *Anatomy and physiology*. John Wiley & Sons.
10. Swaminathan, M. (1988). Essentials of Food and Nutrition, Volume I and II. *The Bangalore Printing and Publishing Co. Ltd., Bangalore*.

## PS 516.1 GENERAL MICROBIOLOGY

**Total No. of Lectures: 42 hours** **Total marks: 70**

**No. of Lectures/week: 3** **Credits 3**

**Course objective:**

*The objective is to provide the students with knowledge about historical aspects of microbiology; classification and life cycle of microorganisms; and techniques used in microbiology.*

*The first unit deals with Historical perspective, comparative morphology and microbial nutrition. The second unit deals with the microbial isolation & animal microbe interaction. The third unit elaborates on viruses, biopesticides and antibiotics.*

**Course Learning Outcomes:** At the completion of this course, students will be able to

CO 1: Acquire knowledge about the microorganisms around us, development of the discipline of Microbiology and the contributions made by prominent scientists in this field.

CO 2: Differentiate between the useful and harmful microorganisms and explain the structure and functions of microscopic organisms

CO 3: Explain s*terilization* of media and assessment of sterility.

CO 4: Understand the importance of microorganisms as model systems in genetics and biochemistry.

**UNIT I** **14L**

Historical perspectives– Robert Hooke, Leeuwenhoek, Spontaneous Generation – for and against, Schwann, Louis Pasteur, Cohn, Relationship between micro-organisms and disease – Lister, Koch, Development of techniques to study microbial pathogens, Immunological studies – Jenner, Fleming.

Comparative morphology, structure and reproduction in archaebacteria - membranes, cell wall, genetics, flagella; eubacteria - membranes, matrix, nucleoid, cell wall and its associations, flagella, endospore; cyanobacteria – structure, classification, nitrogen fixation; yeast – cell envelope, cell wall, matrix, reproduction – budding, spore formation and sexual reproduction; and fungi – characteristics, structure, nutrition, classification, reproduction – asexual spores and fragmentation, sexual – mechanisms and spores, fructifications.

Microbial nutrition – classification based on concentration and chemical nature; nutritional grouping of microorganism – nutrient requirements; Growth kinetics -

mechanisms of growth phases of growth , factors affecting growth and death - oxygen, temperature, pH, salinity; VBNC

**UNIT II** **14L**

Sterilization techniques – chemical and physical methods.

Microbial isolation, enumeration - mass, number, growth; cultivation – aerobes and anaerobes; and preservation – reduced temperature, dehydrated forms.

General account of symbiosis, mutualism – sulphide and methane based mutualism, antagonism, parasitism, commensalism in microorganisms.

Animal microbe interactions: classification, infections, mechanism of action of disease causing agents. treatment and diagnosis – tests to detect the presence of microbe or disease causing agent: Fungal (*Candida albicans*), bacterial (*E. coli, Salmonella typhi*(Widal test)), protozoan (*Entamoeba histolytica, Plasmodium)* and viral (*H1N1* - re-assortment) infections in humans.

**UNIT III** **14L**

Viruses: history, properties of virus, ultrastructure, cultivation, classification (general and Baltimore) and life cycle (lytic and lysogenic cycles) of plant viruses (DNA and RNA viruses) (TMV, CaMV, Gemini virus) animal viruses (DNA and RNA viruses) (enveloped and nonenveloped) (SV40 and HIV), SARS- Covid 19, and bacteriophages (DNA and RNA viruses) (T4, lambda phage - Decision between lysis and lysogeny).

Antibiotics: therapeutic index, classification, Factors influencing the effectiveness of drugs, types (antibacterial, antifungal, antiviral, antiprotozoal), mode of action and mechanism of drug resistance.

Biopesticides: Mode of action and production (Bacterial (*Bacillus thuringiensis*), Fungal (against fungi, nematodes, insects) and Viral (Baculovirus) biopesticides).

**References:**


1. Brock Biology of microorganisms. TB Brock and Madigan (2003). Prentice Hall, 10th Ed.
2. Microbiology. Prescott, Harley & Klein (2002), 5th, 6th, 7th Ed, Mc Graw Hill Pub.
3. Microbiology, Principles & Exploration. J. G.Black (2004) 6th Ed, John Wiley & sons, Inc.
4. Soil Microbiology N.S. S. Rao (1999), 4th Ed, Oxford IBH Pub.
5. Principles of Virology, S. J. Flint (2006), Molecular Biology, Pathogenesis &control ASM press.
6. Microbiology: a Human Perspective. E W Nester,D G Anderson,C. Evans Roberts (2004).4th edition.
7. Foundations in Microbiology. K. P Talaroand A. Talaro. 8th Edition. McGraw Hill.

## PS 517.1P ANALYTICAL TECHNIQUES

**Total marks: 70**

**Practical: 8hr/wk** **Credits: 3**

**Course Objective:**

*This practical course deals with basic techniques that are used to analyse biomolecules. It includes all types of chromatographic, electrophoretic and extraction techniques to extract and analyse biomolecules.*

**Course Learning Outcomes:** At the completion of this course, students will be able to

CO 1: Get hands on training for different types of chromatographic techniques

CO 2: Perform different types of electrophoretic techniques used to separate proteins and analyse the results.

CO 3: Perform various extraction procedures used to extract different molecules from biological samples.

1. Applications of Beer's law- Determination of optimum absorption wavelength for any dye & verification of Beer Lambert law.
2. pH titration of amino acid
3. Separation of amino acids by
    a) circular
    b) 2D-paper chromatography
4. Descending paper chromatography of sugars
5. TLC Sheet preparation & Separation of lipids
6. Flame Photometry
7. Paper Electrophoresis.
8. Column chromatography for plant pigment separation
9. Quantitative estimation of amino acid by Formal titration
10. Extraction of casein from milk by isoelectric precipitation
11. Extraction of lactose from milk
13. Extraction of cholesterol & phospholipids from egg yolk
    a. Quantitative estimation of cholesterol
    b. Quantitative estimation of phospholipids

## PS 518.1P EXPERIMENTAL MICROBIOLOGY

**Total Marks-70**

**Practical: 8hr/wk** **Credits: 3**

**Course Objective:**

The objective of this practical course is to provide hands-on-experience in aseptic techniques, microbial culture, staining procedure and skills in microscopy.

**Course Learning Outcomes:** At the completion of this course, students will be able to

CO 1: Isolate microbes from provided samples and perform bacterial cultures in different media.

CO 2: Perform routine microbiological practices such as sterilization, media preparation, maintenance of microbial culture, and staining.

CO 3: Culture and screen microbes for antibiotic resistance.

1. GLP, Safety practices.
2. Handling and care of laboratory equipment - autoclave, hot air oven, incubator, and laminar airflow.
3. Microbial staining techniques (simple, differential and special staining, Viability test using Fluorescent stains)
4. Isolation techniques, purification and enumeration of microflora in soil, water, air
5. Preservation and maintenance of microorganisms (stock culture, subculture, cold storage, oil storage and lyophilization of the organisms)
6. Microbial characterization based on biochemical tests
7. Determination of microbial growth and factors affecting the growth (temperature, pH)
8. Demonstration of the presence of microflora in the environment by exposing nutrient agar plates to air
9. Isolation of *Rhizobium*
10. Study of fungus and blue green algae.

## PH 511.2 ENZYMOLOGY

**Total No. of Lectures: 56 hours** **Total marks: 70**

**No. of Lectures/week: 5** **Credits: 5**

**Course Objective:**

*The objective is to offer in-depth knowledge about enzymes, which catalyse the diverse biochemical reactions in life processes, providing basic concepts of their kinetics mechanism of action, regulation, inhibition, and wide-ranging applications.*

*The first unit introduces the student to the basic concepts in enzymology. It deals with nomenclature of enzymes. The second unit discusses enzyme assay, isolation and purification. The third unit focuses on the kinetics of enzyme action and its inhibitors. The fourth unit deals with nature and mechanism of enzyme catalysis. The fifth unit deals with protein ligand interaction, metabolic regulation of enzymes as well as application of enzymes.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

CO 1: Classify and explain the general properties of enzymes

CO 2: Describe and use the equations of enzyme kinetics.

CO 3: Describe the catalytic mechanisms of most well-characterized enzymes

CO 4: Describe the mechanisms of enzyme regulation

CO 5: Explain the applications of enzymes in diagnosis, monitoring, and therapy.

**Unit-I 7L**

**General Aspects of Enzymes**– History, Nomenclature and IUB classification of enzymes, significance of numbering system. General characteristics of enzymes, nature of enzyme, enzyme specificity and enzyme active site. Holoenzyme, apoenzyme, cofactors, isoenzymes, multifunctional enzymes, metalloenzymes, metal activated enzymes, coenzymes, monomeric enzymes, oligomeric enzymes and multi-enzyme complexes, - with suitable example. Factors affecting enzyme activity- enzyme concentration, substrate concentration, pH, temperature, activators and inhibitors. Significance of energy of activation.

**Unit-II 7L**

**Purification, Measurement and expression of enzyme activity**- Units of enzyme activity- definition of IU, Katal and specific activity, Enzyme localization, isolation, purification and characterization of enzymes. Criteria of purity of enzymes. Enzyme assay methods- end point and kinetic assay, continuous assay. Coupled assay & its application in quantification of enzyme assays.

**Unit-III 14L**

**Enzymes Kinetics** – Rate of a reaction, order and molecularity. Derivation of Michaelis Menten equation for uni-substrate reactions- Equilibrium and steady state approach. Significance of Vmax, Km, Turnover number ($K_{cat}/K_m$). Linear transformation of Michaelis Menten equation – Lineweaver Burk plot, Eadie-Hofstee, Haynes-Wolf and Cornish-Bowden plot.

**Bisubstrate Reactions** – Cleland's notation with examples for ordered, pingpong, Theorell-Chance and random mechanism, their general rate equations.

**Fast Reaction kinetics** –Characteristics and applications, Methods: Stopped flow, temperature jump.

**Active site structure determination**- Methods of determining active site structure – isolation of ES complex, affinity labelling and chemical modification studies.

**Inhibition kinetics** –Competitive, non competitive, uncompetitive, mixed and product inhibition. Irreversible inhibition – suicide inhibition & its significance, transition state analogs- their application. Determination of $K_i$& it's significance. Primary and secondary plots in enzyme kinetics. Enzyme immobilization techniques and their applications.

**Unit-IV 14L**

**Nature of Enzyme Catalysis** –.

**Nature of Enzyme Catalysis**: Collision theory and transition state theory, Mechanism of catalysis-acid base catalysis, covalent catalysis, nucleophilic and electrophilic catalysis, proximity and orientation and metal ion catalysis

**Mechanisms of Action of Specific Enzymes** – Serine proteases- Classes, Mechanism of Chymotrypsin, Lysozyme, Ribonuclease-A & RNA as enzyme.

Coenzymic action of $NAD^+$, FAD, TPP, PLP, Biotin, CoA, Folic acid and Lipoic acid.

**Unit-V 14L**

**Protein- ligand binding** – Binding of ligands to macromolecules – Hill &scatchard plot, cooperativity, positive and negative cooperativity. Oxygen binding to hemoglobin. Homotropic and heterotropic effectors, aspartyltranscarbamoylase as an allosteric enzyme. Sigmoidal kinetics & their physiological significance, Symmetric (MWC) & sequential models (KNF) for action of allosteric enzymes & their significance.

**Metabolic Regulation of Enzyme Activity** – General mechanisms- Zymogen activation (in digestive enzymes- chymotrypsin), reversible & irreversible covalent modifications of enzymes with suitable example.

**Enzyme application in clinicalbiochemistry**- Aminotransferases, Creatine Kinase, α-amylase, Glucose phosphate dehydrogenase, Cholinesterase ; Isoenzymes of lactate dehydrogenase, alkaline phosphatase in diagnosis and monitoring of disorders. Therapeutic enzymes and Abzymes- applications with suitable examples.

**References:**


1. Palmer, T., & Bonner, P. L. (2007). *Enzymes: biochemistry, biotechnology, clinical chemistry*. Elsevier.
2. Eisenthal, R., & Danson, M. J. (Eds.). (2002). *Enzyme assays: a practical approach* (Vol. 257). Practical Approach (Paperback)..
3. Taylor, K. B. (2002). *Enzyme kinetics and mechanisms*. Springer Science & Business Media..
4. Pandey, A., Webb, C., Soccol, C. R., &Larroche, C. (Eds.). (2006). *Enzyme technology*. Springer Science & Business Media..
5. Shanmugam, S. (2009). *Enzyme technology*. IK International Pvt Ltd..
6. Devasana (T), 2010, Enzymology, Oxford University Press.

## PH 512.2 METABOLISM

**Total No. of Lectures: 56 hours** **Total marks: 70**
**No. of Lectures/week: 4** **Credits: 4**
**Objective:**

*The objective is to enable students to understand the basic concept of bioenergetics. This paper elaborates on the metabolic pathway of carbohydrates and lipids.*

*The first unit explores the metabolism of carbohydrates. The second unit deals with the respiratory chain and electron transport in mitochondria. The third unit explains the general lipid metabolism. The fourth unit discusses the various types of metabolic disorders & integration of metabolism.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

**Unit -I** **14L**

CO 1: Describe the metabolism of carbohydrates, and its regulation

CO 2: Describe the metabolism of lipids and its regulation

CO 3: Explain the importance of high energy compounds, electron transport chain, and synthesis of ATP.

CO 4: Explain the integration of carbohydrate and lipid metabolism

CO 5: Correlate synthesis and breakdown of biomolecules with various metabolic disorders

**Introduction** – Catabolism, anabolism, catabolic, anabolic and amphibolic pathways. **Carbohydrates** – Glycolysis, energetics & regulation. Pathways of utilization of pyruvate – lactate and ethanol fermentation, Pasteur's effect, gluconeogenesis and regulation, Cori cycle and its significance. Citric acid cycle-reactions, regulation, energetic & role as amphibolic pathway. Anaplerotic reactions, glyoxylate cycle and significance. HMP shunt pathway, its physiological significance. Biosynthesis of sucrose, and starch. Glycogenesis and Glycogenolysis- their regulation.

Entry of reducing equivalents for oxidation into mitochondria- malate–aspartate shuttle and glycerol phosphate shuttle.

**Unit -II** **14L**

**Mitochondrial electron transport** –. Organization of respiratory chain complexes, structure and function of the components – Fe-S proteins, cytochromes, sequence of electron carriers based on redox potentials, Q cycle, P/O ratio, oxidative phosphorylation, uncouplers and inhibitors of oxidative phosphorylation. Models to explain oxidative

phosphorylation-Mitchell's hypothesis & proofs, proton motive force, structure of ATP synthase complex, binding change mechanism and mechanism of ATP synthesis.

**Unit -III** **16L**

**Lipids** – Degradation of triacylglycerols and phospholipids – lipases, hormone sensitive lipase, phospholipases. Transport of fatty acids into mitochondria, Fatty acid degradation- β- oxidation of even chain fatty acids & as a source of metabolic water and ATP yield. β- oxidation of odd chain and unsaturated fatty acids, α and ω-oxidation. Biosynthesis of saturated and unsaturated FA and chain elongation reactions. Fatty acid synthase, Regulation of fatty acid biosynthesis and oxidation. Biosynthesis of triglycerides. Metabolism of ketone bodies-synthesis and degradation. Pathways in plants and animals -conversion of linoleate to arachidonate (scheme only).

**Cholesterol Biosynthesis,** Degradation, excretion and regulation. Metabolism of circulating lipids – Chylomicrons, HDL, LDL, VLDL and free fatty acids. Reverse cholesterol transport by HDL.

**Phospholipid Biosynthesis**– *denovo* pathway and inter conversion, biosynthesis of sphingolipids, ether lipids and glycolipids. Degradation and biosynthesis of gangliosides and cerebrosides. Biosynthesis of prostaglandins, thromboxanes and leukotrienes.

**Unit -IV** **12L**

**Metabolic Diseases** – Disorders of carbohydrate metabolism – Diabetes mellitus, classification, etiology and its management, laboratory investigations – GTT, Hb analysis(glycohaemoglobins)**.** Inborn errors of carbohydrate metabolism – glycogen storage diseases, galactosemia, lactose intolerance, pentosuria.

**Disorders of Lipid Metabolism**- Lipid levels in pathological conditions, Diagnostic tests for apolipoproteins, HDL-cholesterol, LDL-cholesterol, triglycerides disorders. Consequences on metabolism – foam cell formation. Types of lipoprotein modification-glycosylation & oxidation. Inherited human diseases with membrane lipid accumulation-Tay-sachs disease, Nieman-Pick disease, Fabry's disease. **Cardiovascular Disorders** – Major Cardiovascular diseases – Atheroscherosis – risk factors, pathogenesis, Diagnosis and prognosis.

**Integration of carbohydrate and lipid metabolism, glucose paradox.**

**References:**


1. Cox, M. M., & Nelson, D. L. (2017). *Lehninger principles of biochemistry*. New York: Wh Freeman
2. Berg, J. M., Tymoczko, J. L., &Stryer, L. (2002). Biochemistry.
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4. White, A., Handler, P., Smith, E., &StettenJr, D. (1959). Principles of biochemistry. *Principles of Biochemistry.*, (Edn 2).
5. Voet, D., Voet, J. G., & Pratt, C. W. (2016). *Fundamentals of biochemistry: life at the molecular level*. John Wiley & Sons.
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8. Murray, R. K., Granner, D. K., Mayes, P. A., & Rodwell, V. W. (2014). *Harper's illustrated biochemistry*. Mcgraw-hill.
9. West, E. S., Todd, W. R., Mascon, H. S., & Van Bruggen, J. T. (1974). *Textbook of biochemistry*. Oxford and IBH Publishing.
10. Buchanan, B. B., Gruissem, W., & Jones, R. L. (Eds.). (2015). *Biochemistry and molecular biology of plants*. John wiley& sons.

## PH.513.2P Practical Enzymology

**Total Marks: 70**

**Practical:8hr/wk** **Credits: 4**

**Course Objective:**

*This course aims at understanding practical aspects of kinetic reactions catalysed by enzymes with one or more than one substrate. The course covers various aspects of isolation, purification and characterization of enzymes using their kinetic reactions.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

1. Enzyme assay & Kinetic studies of enzyme Salivary amylase

CO 1: Demonstrate practical understanding of enzyme kinetics and its applications.

CO 2: Demonstrate practical applications of monosubstrate and bisubstrate assays and an overall understanding of using various biochemical kinetic reactions for isolating and purifying specific analytes.

CO 3: Isolate and purify enzymes using downstream processing

CO 4: Conduct quantitative assay of clinically important enzymes

a. specific activity
b. effect of pH
c. effect of temperature
d. energy of activation,
e. effect of substrate,
f. Km & Vmax determination with MM plot, LB plot, Eadie-Hoftee plot *etc.*

2. Assay of invertase from Calatropis/ Yeast
3. Assay of protease from papaya,
4. Assay of acid/alkaline phosphatase
5. Bisubstrate enzyme assay (minimum one)
   a. SGOT
   b. SGPT
   c. LDH
6. Isolation of microbe for enzyme (Eg. Amylase, Protease) production
7. Inoculum preparation & Scale up of Inoculum
8. Extraction of Enzyme
9. Downstream processing by
   a. ammonium sulphate precipitation
   b. Ion exchange chromatography
   c. Fold purity calculation
   d. Native PAGE
   e. SDS-PAGE & molecular weight determination

## PS 514.2 RESEARCH METHODOLOGY AND ETHICS

**Total No. of Lectures: 42 hours** **Total marks: 70**

**No. of Lectures/week: 3** **Credits : 3**

**Course Objective:**

*The primary objective of this course is to acquaint students with fundamentals of research methods, introducing them to the basic concepts used in research. It includes discussions on sampling techniques, research designs and techniques of analysis.*

*This paper gives the students training in soft skills required to analyse and interpret their research findings. The first unit is devoted to research methodology, clear understanding of the meaning and purpose of research in academics, research philosophy and strategies of research. Second unit is devoted to biostatistics, various tests and parameters for data analysis. Third unit deals with understanding the ethical issues and practices in research with an awareness of rights and obligations of research participants and also to understand the process of intellectual property rights and its different forms and implications.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

**Unit-I** **12L**

CO 1: Demonstrate an understanding of research design, procedures of sampling, data collection, analysis and reporting.

CO 2: Describe the appropriate statistical methods required for a particular research design and apply appropriate statistical methods for analyzing one or two variables..

CO 3: Display an understanding of imperative issues in research ethics, like responsibility for research, scientific misconduct and ethical evaluation

CO 4: Demonstrate awareness on Intellectual property rights and patents

**Research methodology:**

Meaning and importance of Research – Types of Research – Selection and formulation of Research Problem – Research Design. Types, Methods & Classification of Research.

**Sampling techniques**- population & sample, types of samples and sampling techniques.

**Data Collection**: Objective and Classification of Data, Types of data: Primary, Secondary and Tertiary Data. Graphical representation of data- line graph, histogram, pie chart, exponential growth, Scaling technique.

**Design of experiment**- Completely randomized design, randomized block design.

Reporting and thesis writing – Structure and components of scientific reports -Types of report – Technical reports and thesis – Significance – Different steps in the preparation – Layout, structure and Language of typical reports – Illustrations and tables- Bibliography, referencing and footnotes.

**Unit –II** **20L**

**Biostatistics** –Frequency distribution and frequency polygon. Graphic representation – Line graph, histogram, pie chart. Measures of central tendency- mean, median, mode, quartiles and percentiles. Measures of dispersion; variance, standard deviation, standard error, measures of skewness and kurtosis.

**Probability and distributions**: sample space, events. Definition of probability (frequency approach), independent events. Addition and multiplication rules, conditional probability. Examples- Binomial, poisson and normal distributions.

**Tests of significance**: Sample test ( chi square, t-test, F –test), large sample test(z test), p value of the statistics, ANOVA- one way and two way.

**Bivariate data**: scatter plot, correlation coefficient - positive and negative correlation, regression coefficient.

**Unit III** **10L**

**Research Ethics:**

Ethics – meaning and definition, Ethics versus moral philosophy, nature of moral judgments and reactions. Rights and obligations of Research Participants. Scientific conduct – ethics with respect to science and research, intellectual honesty and research integrity. Scientific misconduct – falsification, fabrication and plagiarism , Self-plagiarism. Publication ethics – meaning and importance, conflicts of interest, publication misconduct – meaning, problems that lead to unethical behaviors, types of publication misconduct, identification of publication misconduct, complaints and appeal. Redundant publication – duplicate and overlapping publications, salami slicing. Citation index. H-index, i-index,

Violation of public ethics, authorship and contributor ship. Predatory publishers and journals – software to identify predatory publications – journal finder/journal suggestions tools by JANE, Elsevier journal finder, Springer journal suggestions, UGC care list, Scopus, Web of Science. Selective reporting and misinterpretation of data. Best practices/standard setting initiatives and guidelines.

**Intellectual property rights:** Different types of intellectual property rights, patents-national and international patents. Patenting procedures, patent applications & rules governing patenting. Patenting of genes and products. Ethical and moral issues in biological and biotechnological research.

**References:**


1. Kumar, R. (2018). Research methodology: A step-by-step guide for beginners. Sage..
2. Holmes, D., Moody, P., Dine, D., &Trueman, L. (2017). Research methods for the biosciences. Oxford university press..
3. Kothari, C. (2017). research methodology methods and techniques by CR Kothari. Published by New Age International (P) Ltd., Publishers, 91..
4. Hoel, P. G. (1960). Elementary statistics. Elementary statistics..
5. Khan, I. A., & Khanum, A. (2004). Fundamentals of biostatistics. Ukaaz..
6. Rao, P. S., & Richard, J. (2012). Introduction to biostatistics and research methods. PHI Learning Pvt.Ltd..
7. Indrayan, A., & Satyanarayana, L. (2006). Biostatistics for medical, nursing and pharmacy students. PHI Learning Pvt. Ltd.
8. Dutfield, G. (2009). Intellectual property rights and the life science industries: past, present and future. World Scientific.
9. Palfrey, J. (2011). Intellectual property strategy. Mit Press.

## PS 515.2 BIOTECHNOLOGY

**Total No. of Lectures: 42 hours** **Total marks: 70**

**No. of Lectures/week: 3** **Credits : 3**

**Course Objective:**

*This paper offers basic aspects of microbial technology, fermentation, products of fermentation, introduction and application of animal cell culture, plant tissue culture and their role in agriculture and environmental pollution control.*

*The first unit elaborates on microbial technology- basic aspects of fermentation bioprocess. The second unit elaborates on animal cell culture techniques and its applications. The third unit elaborates on Plant Biotechnology and concepts of Environmental Biotechnology.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

**Unit 1 10L**

CO 1: Explain strain improvement methods, isolation of industrial important microorganisms, different types of fermentation process and different recovery process of the final product formed.

CO 2: Demonstrate an understanding of animal cell culture, cell lines, application in tissue engineering and hybridoma technology.

CO 3: Explain basic concepts od Plant Biotechnology and its applications in agriculture like micro-propagation, haploid plants, embryo culture, hybrids

CO 4: Enlist the applications of microbiology in waste management, environmental pollution control.

**Microbial Technology** – Isolation and improvement of industrially important strains.

Fermentors-Design of fermentation media, Basic design of a fermentor, inoculum development, batch, fed batch and continuos mode of fermentations.

Sterilization- Thermal death kinetics, sterilization of medium, air and fermentors, concepts of process variables and scale up.

Bioreactors-for microbes, plant cells, and animal cells.

Microbial production & Downstream processing of Vitamins (B12), enzymes (amylase), organic acid (citric acid), amino acid (lysine), solvents (acetone, butanol), antibiotics (penicillin), single cell proteins, ethanol-wine & beer.

Unit II 12L

**Animal Cell Culture** – Culture techniques, aseptic conditions, Equipment and materials for animal cell culture. Different constituents of culture medium, types of media and their application. Basic techniques of mammalian cell culture in vitro; disaggregation of tissue and primary culture. Cell lines-characteristics and routine maintenance.Cell viability and cytotoxicity. Mycoplasma detection & control. Characterization of the cultured cells-measuring parameters of growth. Cell synchronization, Somatic cell fusion, Cell cloning and cryopreservation. Applications of animal cell culture- Organ and histotypic cultures. Differentiated cells in culture & its application. Tissue engineering (e.g. Skin). Adult and embryonic stem cells and their applications.

Hybridoma technology-monoclonal antibodies, cell fusion, selection of hybrids, protoplast fusion & HAT medium, screening assays, purification & application of monoclonal antibodies.

**Unit III 20L**

**Plant Biotechnology**

Plant tissue culture; Laboratory design, aseptic conditions, methodology, media. Techniques of callus cultures, meristem cultures, anther culture, embryo culture, protoplast culture, micropropagation, somatic embryogenesis and somaclonal variation, synthetic seeds; germplasm conservation and its application.

Agriculture- Breeding in plants (including marker assisted selection). Various methods of gene transfer in plants, Development of transgenic plants- insect resistance (BT cotton), improved quality, (golden rice, delayed fruit ripening), herbicide tolerant, stress resistant plants

**Environmental Biotechnology**

Microbial degradation of toxic chemicals- petrochemicals, organo halogens and phosphates. Principles of microbial bioremediation, microbiological treatment of solid waste. Biofertilizers and biofuels. Biological treatment of liquid wastes. Environmental release and monitoring of GMOs(Genetically Modified organisms).

**References**

1. Asthana, D. K., & Asthana, M. (2005). Environment –Problems & solutions (2nd ed.). S.Chand&company,New Delhi.

2. Balts, R. H., Demain, A. L., & Davies, J. E. (1999). Manual of Industrial Microbiology and Biotechnology (2nd ed.). ASM Press.
3. Basic Cell Culture (Practical Approach) 2nd (second) Edition published by Oxford University Press, USA (2002) (2nd ed.). (2002). Oxford University Press, USA.
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5. Chawla, H. S. (2005). Introduction to Plant Biotechnology (5th ed.). Enfield, NH: Science.
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8. Freshney, I. R. (2011). Culture of Animal Cells: A Manual of Basic Technique (6th ed.). John wiley& Sons.
9. Ghosh, T. K. (2005). Biotechnology in Environmental Management. APH Publishing Corporation.
10. Glazer, A. N., &Nikaido, H. (2007). Microbial Biotechnology: Fundamentals of Applied Microbiology (2nd ed.). Cambridge University Press.
11. Jogdand. (2004). Environmental Biotechnology (2nd ed.). Himalaya pub house.
12. Kumar De, A. (2006). Environmental Chemistry (5th ed.). New Age International.
13. Moo-Young, M. (2019). Comprehensive Biotechnology (3rd ed.). Pergamon.
14. Odum, E. (2005). Fundamentals of Ecology (5th ed.). Cenage Learning.
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19. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2005). Principles of Fermentation Technology (3rd ed.). Butterworth-Heinemann.

## PS 516.2. NEUROBIOCHEMISTRY

**Total No. of Lectures: 42 hours** **Total marks: 70**

**No. of Lectures/week: 3** **Credits: 3**

**Course Objective:**

*The aim of this paper is to provide the students with the basic understanding in Biochemistry of the developing nervous system, nature of neurotransmitters and their potential role in the vast majority of neurological diseases.*

*The first unit introduces the nervous system and its components. The second unit elaborates on the neurotransmission. The third unit deals with neurological diseases.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

| | |
|---|---|
| CO 1: | Demonstrate basic understanding of the nervous system and its functions. |
| CO 2: | Explain basic concepts of physiology and structure of nervous system |
| CO 3: | Describe the nature of neurotransmitters and its role in neuronal signal transmission |
| CO 4: | Demonstrate concrete understanding of neuronal processes that involves key aspects of learning and memory. |

**Unit-I** **14L**

Neurons: Introduction to neurons, components of neurons, classification and types of neurons,

cytology of neurons, dendrites structure and function, axons structure and functional aspects,

ultrastructure, myelination and synapses. Sensory system, Glial cells: Structure and function of

glial cells, Different types of glial cells: astrocytes, oligodendrocytes and Schwann cells, Types of astrocytes – type I & II astrocytes, fibrous and protoplasmic astrocytes, Importance of astrocytes in glutamate metabolism and blood brain barrier.

**Unit II** **14L**

Neurotransmission- voltage-Gated Ion Channels, action Potentials, neurotransmitters and their Receptors, Role of voltage-gated and ligand-gated ion channels in neural transmission, ion channels and signaling in nerve cells, neurotransmitter synthesis and metabolic mechanisms at the synapse, release and re-uptake/degradation of classical neurotransmitters and peptide transmitters. Acetylcholine synthesis, storage and release. Nicotinic and muscarinic receptors; Catecholamine: Biosynthesis, storage and release; dopamine, adrenergic receptors. Serotonin: synthesis, action and distribution, role of serotonin receptors in behaviour, molecular sites and action in the CNS; GABA and glycine: synthesis, uptake and release; receptors of GABA and glycine.

**Unit III** **14L**

Neurochemical and molecular mechanisms of peripheral neuropathy; diseases involving myelin; Multiple sclerosis and other demyelinated disorders; Genetic disorders of Lipid, glycoprotein, and Mucopolysaccharide metabolism; Duchenne Muscular dystrophy: Molecular, genetic aspects and diagnostic characteristics of Ischemia and hypoxia; Epileptic seizures; Genetics and diagnosis of Huntington disease and other triplet repeat disorders; Alzheimer's disease: Molecular, genetic, immunological aspects and diagnostics Alzheimer's disease and Parkinson's disease and Prion Diseases.

**References:**


1. David L. Nelson and Michael M. Cox. (2011). Lehninger Principles of Biochemistry, 5th Edition, W.H. Freeman & company.
2. LubertStryer, Jeremy M. Berg, John L. Tymoczko,. (2002). Biochemistry, 5th Ed., Freeman & co, New York.
3. Robert K. Murray, Daryl K. Grammer, Peter A. Mayer, Victor W. Rodwell (2009). Harper's Biochemistry, 28th Ed., Tata mcgraw- Hill publishing company limited, New Delhi.
4. Donald Voet, Judith G. Voet, Charlotte W. Pratt (2011). Fundamentals of Biochemistry, Life at the molecular level. 4th Ed., John wiley& sons, Inc.
5. Alberts B, Bray D, Lewis J, Raff M, Roberts K, Watson J. D. (2008). Molecular Biology of the cell. 4th edn, Garland Publishing, Inc., New York.
6. Cooper, Geoffrey M (2007). The Cell-A Molecular Approach, 2nd ed., Sunderland (MA): Sinauer Associates, Inc
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8. Verkhratsky, (2007). Glial Neurobiology, A Text Book, Wiley.
9. Kendel (2013), Principles of Neural Science (5th edition), McGraw Hill,
10. Squire (2013), Fundamental Neuroscience (4th Edition), Elsevier.


## PS 517.2P PRACTICAL BIOTECHNOLOGY

**Total marks-70**

**Practical:8hr/wk** **Credits: 3**

**Course Objective:**

*The objective of this practical course is to provide hands on experience in plant and animal cell culture; acquaint students with requirements of the tissue culture laboratory, sterilization, media preparation and culturing biological specimens in laboratory condition.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

1. Sterilization of tissue culture room by fumigation

CO 1: Gain practical knowledge on tissue culture laboratory set-up, sterilization and media preparation

CO 2: Perform animal and plant cell culture techniques

CO 3: Perform toxicity and cell viability assays on animal tissues and conduct water quality testing

2. Preparation of media and Balanced salt solutions
3. Cell disaggregation by warm trypsin/cold trypsin method for primary culture
4. Primary explant culture (animal tissue)
5. Estimation of cell viability by dye exclusion method (animal tissue)
6. MTT assay (animal tissue)
7. Seed culture
8. Embryo culture
9. Stem & leaf for callus
10. Carrot –callus
11. Induction of shoot & root in callus
12. Seed immobilization- Preparation of synthetic seeds
13. Separation of lymphocytes from blood by centrifugation
14. Total dissolved solids of water
15. Dissolved oxygen (DO) of water
16. Biological oxygen demand (BOD) of water
17. Chemical oxygen demand (COD) of water

## PS 518.2P Experimental Neurobiochemistry

**Total marks-70**

**Practical:8hr/wk** **Credits : 3**

**Course Objective**

*The objective of this paper is to enable the students to attain practical knowledge in neurobiochemistry, including analysis of behavioural parameters, effects of drugs/toxins on the brain. This practical paper also focuses on the tissue preparations for various biochemical and cytogenetic assays.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

CO 1: Quantify and analyse the effect of drugs/toxins on brain tissue

CO 2: Prepare tissue homogenates required for various biological assays and perform biochemical and histological assays to understand neuronal activity

CO 3: Evaluate the behavioural changes that take place under conditions of stress and anxiety and apply the information obtained

1. Isolation and preparation of brain tissue homogenates
2. Effect of various psychotic drugs on brain tissue
3. Cytotoxicity of heavy metals (Lead, cadmium) on brain cells
4. Evaluation of memory and learning using radial maze test
5. Study of brain development in chick embryo
6. Behavioural analysis software tools and analysis
7. Study of blood-brain barrier models for drug transport
8. Assessment of bioavailability of toxicants/drugs in brain tissue
9. Acetyl choline esterase activity in brain cells
10. Measurement of anxiety and antidepressant activity using elevated plus maze

## PO 519.2. Biochemistry of Diseases

## (Open Elective-I)

**Total No. of Lectures: 42 hours** **Total marks: 70**

**No. of Lectures/week: 3** **Credits 3**

**Course objective:**

*The objective of this paper is to enable the students to understand basic health, common diseases, general check-ups& medical diagnostic tests.*

*The first unit gives information about anatomy of the human body, healthy diet, and general check-ups. The second unit deals with some common infectious disease, tests to diagnose them & antidote therapy. The third unit elaborates on systemic pharmacology and drugs used for various diseases.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

CO 1: Demonstrate an understanding of the mechanisms of diseases- cause, transmission, detection, treatment and prevention.

CO 2: Understand general health check-ups, diagnosis and samples for disease analysis.

CO 3: Relate to any existing or emerging infection as well as will learn about drug resistance and its mechanisms.

CO 4: Acquire know-how to health research and develop new tools for their management.

**Unit I** **12L**

**Introduction -** Location of organs. Introduction on Concepts of macro and micro nutrients, healthy diet, Atkins diet, essential nutrients and their classification. Energy value of food-Food as source of energy.

General health, syndrome and common diseases – communicable and non-communicable diseases. General check up: Blood group, Hb, height and weight, waist to hip ratio, electro cardio gram. Samples for analysis: Blood, urine, pleural fluid, synovial fluid, cerebrospinal fluid and tissues and histology.

**Professional hazards**: High risk groups (farmers, heavy duty machine workers, Corporate workers, athletes).

**Unit II** **10L**

**Infectious diseases**: Cause, Symptoms and treatment/prevention- Bacterial infections (Tuberculosis, Salmonella, Cholera),Viral infections (Hepatitis A,B,C), H1N1, chikungunya, Dengue ), STDs( Chlamydia, Syphilis, Gonorrhea, HIV). Pregnancy and infections.

**Antidotal therapy**: types of antidotes: universal, simple & multiple antidotes: definition & examples. Antidotal procedures: decrease absorption of toxicants by emetics and chelating agents.

**Adverse effect of Drugs**:- Paracetamol, Aspirin ,Solvent toxicity-Methanol and Chemotherapeutic drugs.

**Pharmacodynamics**- types of action, Pharmcodynamic /pharmacokinetic (PK/PD) correlation.

**Unit III** **20 L**

**Mechanism of drug action and adverse reaction of following drugs:**

**Analgesic drugs**: Codeine, Morphine

**Drugs of abuse**: Alcohol, LSD, nicotine.

**Antipyretic drug:** Paracetamol

**Respiratory Drugs: salbutamol, montelukast**

**Anti-emetics**: metaclopramide,

**Drugs in peptic ulcer**: cimetidine.

**Diuretics**: chlorothiazide

**Cardiovascular drugs**-in heart failure: digoxin,

**Vasodilators:** Nitroglycerine.

**Anti-inflammatory drugs**- NSAIDS: aspirin,

**Antidiabetics:** metformin, glimepiride & Insulin.

**Steroids**: estradiol, methyltestosterone, dexamethasone.

**Antimicrobial agents**- Penicillin, isoniazid, amphotericin B, acyclovir, chloroquine.

**Anti-cancer agents:** Cyclophosphamide, mercaptopurine, vinblastine, vincristine

**References:**


1. Tripathi, K. D. (2013). Essentials of medical pharmacology. JP Medical Ltd.
2. Hodgson, E. (Ed.). (2004). A textbook of modern toxicology. John Wiley & Sons.
3. Omkar. (2014). Concepts of toxicology. Vishal Publishers.
4. Thomas, L. (6th Ed), (2008). Foyes principles of medicinal chemistry. WolterKluPublishers.
5. Joel, G. Lim. (10th Ed). (2001). Goodman and Gilman pharmacological chemistry. Tata McGrawhill.
6. Richard, C. (2004). Medical toxicology. Lippincott.
7. Curtis, D. (6th Ed). (2001). Casarett and Doull's toxicology. Oxford University Press.

## PH 511.3 MOLECULAR BIOLOGY

**Total No. of Lectures: 56 hours** **Total marks: 70**

**No. of Lectures/week: 5** **Credits: 5**

**Course objective:**

*The objective is to offer detailed knowledge about the central dogma, concept of genome, mechanisms of DNA replication, gene expression and translation in prokaryotes and eukaryotes.*

*The first unit introduces the concept of replication of prokaryotic as well as eukaryotic DNA & its regulation. The second unit elaborates on transcription in prokaryotic as well as eukaryotic systems & prokaryotic transcriptional regulation. The third unit deals with translation in both prokaryotes as well as eukaryotes. The fourth unit elaborates on genetic basis of cellular differentiation & Eukaryotic gene expression regulation and fifth unit deals with cell cycle.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

CO 1: Give an overview of the central dogma of life and the historical discoveries that led to our current understanding of molecular mechanisms of life

CO 2: Describe the organization of prokaryotic and eukaryotic chromosome

CO 3: Explain the processes of transcription/translation, posttranscriptional/ posttranslational modifications.

CO 4: Differentiate *prokaryotic and eukaryotic* gene expression and regulation

CO 5: Identify the stages of the cell cycle, and explain the important checkpoints that a cell passes through during the cell cycle

**Unit -I** **14L**

**DNA Replication & regulation**

Information flow in biological systems; central dogma of molecular biology. Modes of DNA Replication. Experimental evidences for semi conservative replication-Messelson-Stahl experiments. Prokaryotic *E.coli* DNA replication, eukaryotic DNA replication, origin and replication fork, fidelity of replication,DNA Replication in viruses - single stranded DNA virus, rolling circle model, replication of mitochondrial DNA. direction of replication, discontinuous replication - Okazaki fragments. DNA polymerase I, II and III,

DNA ligase, DNA topoisomerases, Role of replication inhibitors. Fine structure of the prokaryotic and eukaryotic gene - promoters, introns, exons, other regulatory sequences, enahancers, silencers, function of introns. Nearest neighbour base frequency analysis

**Unit -II** **12L**

**Transcription & elucidation of genetic code**

Prokaryotic and Eukaryotic Transcription-initiation- abortive cycle, elongation and termination. transcription factors & machinery. various protein motifs involved in DNA protein interaction during transcription, RNA processing, modification in RNA: $5^{l}$-Cap formation; $3^{l}$-end processing and polyadenylation, Different modes of RNA splicing, RNA shuffling, RNA Editing, mRNA stability, RNAs in gene regulation, siRNA, miRNA and gene silencing, genomic imprinting, RNA export.

**Unit -III** **10L**

**Regulation of Gene Expression in prokaryotes-** Transcription activators and repressors, Regulation of gene expression in prokaryotes: House keeping genes, constitutive genes and regulatory genes. Operon concept, Lac operon, structure and regulation. Arabinose operon, Gal operon- role of two operators, Tryptophan operon- Transcriptional control by attenuation in tryptophan operon. Role of riboswitches.

**Regulation of Eukaryotic gene expression:** Regulation at the level of genome-DNA amplification, DNA rearrangement, role of nucleosome structure, Chromatin remodeling, SWI/SNF complex, Role of histone modification.

**Unit -IV** **12L**

**Elucidation of Genetic code**- Experimental studies of Nirenberg and Khorana. evolution of genetic code and codon usage, General features of genetic code. Triplet binding techniques, degeneracy, wobble hypothesis.

**Protein synthesis and processing-** Translation in Prokaryotes and Eukaryotes: 3D structure of prokaryotic and eukaryotic ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination of protein synthesis. Role of mRNA and tRNA, aminoacylation of tRNA, tRNA- identity, aminoacyl tRNA synthetase, translational proof-reading, translational inhibitors, post-translational modification of proteins. signal sequence, N-end rule, PEST and other sequences, protein splicing.

**Unit -V** **8L**

Translational and Post translational control. Hormones [steroid (glucocorticoid) and peptide hormones] and Environmental factors (hypoxia, infection, stress) affecting gene expression.

**Cell Cycle** – Molecular aspects of cell division -Mitosis and Meiosis, regulation by cyclins and CDKs .Programmed Cell Death (apoptosis), factors affecting apoptosis- p53 and bcl2. Aging & Cellular senescence.

**References:**


1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., & Watson, J. D. (1993). Molecular Biology of the Cell. Third. Garland Science.
2. Cooper, G. M. (2007). Cell: A Molecular Approach, + a Student Handbook in Writing in Biology. Sinauer Associates..
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4. Karp, G. (2009). Cell and molecular biology: concepts and experiments. John Wiley & Sons.
5. Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2009). Lewin's genes X. Jones & Bartlett Publishers..
6. Watson, J. D. (2004). Molecular biology of the gene. Pearson Education India..
7. Robert F. Weaver (2008), Molecular Biology, McGraw-Hill international Edition.
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## PH 512.3 NITROGEN METABOLISM & PLANT BIOCHEMISTRY

**Total No. of Lectures: 56 hours** **Total marks: 70**

**No. of Lectures/week: 4** **Credits: 4**

**Course Objective:**

*The objective is to offer detailed knowledge about the fundamental aspects of Nitrogen metabolism, plant physiology and metabolism in plants*

*The First unit deals with general nitrogen and amino acid metabolism. The Second unit deals with Protein, Nucleotide metabolism and its disorders. The third unit deals with Photosynthesis, plant hormones and secondary metabolites. The fourth unit deals with Physiology of plants.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

CO 1: Discuss nitrogen metabolism and general mechanisms of amino acid metabolism.

CO 2: Describe pathwaysof degradation of proteins, purines and pyrimidines and Inborn errors of amino acid degradation

CO 3: Identify important metabolites in plants and animals that are important to understand the significance of various metabolic pathways.

CO 4: Explain the process of photosynthesis; metabolism of photo assimilates and therole of plant hormones.

CO 5: Discuss photobiology and stress physiology in plants

**Unit –I** **14L**

**Nitrogen metabolism:** Importance of nitrogen in biological systems, nitrogen cycle. Nitrogen fixation - symbiotic and non-symbiotic, nitrogenase complex, energetics and regulation. Formation of root nodules in legumes. Assimilation of Nitrate, ammonia and sulphur into aminoacids.

**General Mechanisms of Amino Acid Metabolisms**- ketogenic and glucogenic amino acids. Common intermediates of amino acid degradation (flow chart). Overview of amino acid biosynthesis, synthetic pathways for nonessential & flow chart for essential amino acids. Synthesis of aromatic amino acids, regulatory mechanisms (Flow charts with suitable examples) in the biosynthesis of amino acids in *E.coli*.Heme biosynthesis and degradation. Biosynthesis of phosphocreatine, glutathione and gramicidine. Biosynthesis

of neurotransmitters-GABA, serotonin, epinephrine, polyamines- spermidine, spermine

**Unit -II** **14L**

**Proteins**- General mechanisms of degradation in cells (Ubiquitin-proteosome pathway, lysosomal pathway), Degradation and biosynthesis of glycoproteins, proteoglycans.

**Purines and Pyrimidines**- Pathways of degradation of nucleic acids in cells, Salvage pathways, denovo biosynthetic pathways, regulation of biosynthesis. Conversion of nucleotides to deoxynuclotides.

Biosynthesis of $NAD^+$, FAD and coenzyme A.

**Disorders with aminoacid & nucleic acid metabolism**: Inborn errors of amino acid degradation - phenyl ketonuria, alkaptonuria, malple syrup urine, hyperhomocysteinemia& its association with disease, Porphyrias- common genetic defects & symptoms. Gout and Lysch-Nyhan syndrome. Mechanism of action of methotrexate, 5-fluorouridine, Azathymidine.

**Unit –III** **14L**

**Photosynthesis** –Bacterial photosynthetic apparatus and Bacterial photosynthesis (Purple bacteria). Photosynthetic apparatus in plants-Structure of chloroplasts, Photoreceptors- chlorophyll, bacterial rhodopsin, light harvesting complex. photosystem I and II, their location, mechanism of Quantum capture & energy transfer between photosystems- ferrodoxin, plastocyanin, plastoquinone, carotenoids. The Hill reaction, photo-phosphorylation, water splitting complex, calvin cycle, regulation, RUBISCO-substrate specificity, Photorespiration. $C_4$& CAM metabolism. Light activation of enzymes, regulation of photosynthesis,

**Plant hormones:** Biosynthesis, storage, breakdown and transport; physiological effects and Mechanism of action of Auxines, Gibberlines, Cytokinins, Ethylene, Abscisic acid,

Seed dormancy, Inception of germination, Germination and growth regulators.

**Secondary metabolites** - Biosynthesis of terpenes, phenols and nitrogenous compounds and their roles.[The shikimate and phenyl propanoid pathways (scheme only)].

**Unit –IV** **14L**

**Solute transport and photoassimilate translocation:** Uptake, transport and translocation of water, ions, solutes and macromolecules from soil, through cells, across membranes, through xylem and phloem; transpiration; mechanisms of loading and unloading of photoassimilate**.**

**Sensory photobiology:** Structure, function and mechanisms of action of phytochromes, cryptochromes and phototropins; stomatal movement; photoperiodism and biological clocks. bacterial and plant two-component systems, light signaling in plants,

**Stress physiology:** Responses of plants to biotic (pathogen and insects) and abiotic (water, temperature and salt) stresses; mechanisms of resistance to biotic stress and tolerance to abiotic stress.

**Host parasite interaction:** Recognition and entry processes of different pathogens like bacteria, viruses into plant host cells, alteration of host cell behavior by pathogens, virus-induced cell transformation, pathogen-induced diseases in plants.

**References:**


1. Raymon S. (2014). Biochemistry, Jones and Bartlett publisher
2. Gleason F, Chollet R, (2012), Plant Biochemistry, Jones and Bartlett publisher
3. PM Dey and JB Harborne, (2013). Plant Biochemistry, Elsevier India Pvt Ltd.
4. Caroline B, Martin Steer, Alyson T, (2008). Plant Biochemistry, Garland science.
5. Cox M and Nelson D. (2011). Lehningers Principles of Biochemistry, Ed 5, W H Freeman and co.
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7. Voet D and Voet JG (2011). Biochemistry, Ed 4, John Wiley and sons.
8. Voet D (2013). Principles of Biochemistry, John Wiley and sons.
9. Croy RRD. (1993). Plant Molecular Biology, Birla Publication.
10. Verman V (2011). Plant Physiology, Ane books.
11. Stewart P and Globig S. (2011). Photosynthesis: genetic environmental aspects, Apple academic press.
12. Yashpal A (1993). Photosynthesis, Photoreactions to plant productivity, Oxford University press
13. Goodwin and Mercer (2003). Introduction to plant Biochemistry, CBS publication

## PH 513.3P Metabolism and Clinical Biochemistry

**Total marks: 70**

**Practical:8hr/wk** **Credits: 4**

**Course Objective:**

*The objective of this practical course is to provide hands-on-experience in clinical aspects of laboratory which includes analysis various haematological and biochemical changes in blood and urine samples.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

CO 1: Demonstrate ability to perform experiments to estimate metabolic parameters.

CO 2: Perform microscopic & chemical analysis of Blood & urine

CO 3: Analyse and interpret clinical and biochemical changes taking place in blood and urine under normal and pathological conditions.

CO 4: Identify the normal and abnormal constituents present in urine samples and quantify them.

1. Glycogen extraction and quantification from fed and fasting mice liver and muscle.
2. Electrophoresis of lipoproteins/ Hemoglobin/LDH
3. Photo oxidation of methylene blue
4. Photo synthetic reduction of 2, 6 dichlorophenol, indophenol
5. Estimation of pyruvate/lactate/ alpha ketoglutarate (Keto acids)
6. Microscopic & chemical analysis of Blood & urine

   i. Quantitative Urine analysis

   a. Titrable acidity
   b. Organic acids
   c. Aminoacids
   d. creatinine,
   e. urea,
   f. uric acid,
   g. pentose
   h. glucose
   i. qualitative tests of urine

   ii. Blood Analysis

a. Blood cell-Total count, differential count,
b. Haemoglobin
c. Platelet aggregations,
d. Blood glucose,
e. Urea,
f. Uric acid
g. Creatinine,
h. Bilirubin
i. A/G ratio,
j. HDL and LDL cholesterol determination

## PH 514.3P CELL & MOLECULAR BIOLOGY

**Total marks: 70**

**Practical: 8hr/wk** **Credits: 4**

**Course objective:**

*This practical paper deals with various techniques used to study the cellular and molecular basis of cells from different biological sources. It also deals with study of cell division phases and staining techniques used for different types of cells from biological samples.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

**Course Learning Outcomes:**

CO 1: Evaluate and apply knowledge of modern techniques in cellular biology for observation and identification of tissues and cells

CO 2: Extract DNA, RNA and perform their analysis at molecular level.

CO 3: Learn the different phases of cell division using molecular techniques.

CO 4: Handle,maintain Drosophila melanogaster and perform experiments related to the model organism

1. Micronucleus test
2. Study of mitosis in onion root tips and determination of mitotic index & inhibition of mitosis by mitotic inhibitors
3. Study of plasmolysis in cells of Rheo leaves
4. Preparation of erythrocyte membranes
5. Preparation of tissues for cytological studies and microtomy
6. Histology-Hematoxylin –Eosin counter staining
7. Histochemical localization of macromolecules-
    a. Localization of carbohydrates- PAS
    b. Localization of proteins- ninhydrin
    c. Localization of DNA-Feulgen stain
8. Extraction of DNA from Bovine Spleen/coconut endosperm, purification, quantification
9. Investigation of the structure and the bond strength of DNA(Cot Value)
10. Extraction of RNA from coconut endosperm, purification of RNA
11. Salient feature of *Drosophila melanogaster*, Maintenance of *Drosophila melanogaster* cultures
12. Study of mutants of *Drosophila melanogaster*
13. Demonstration of sex chromatin
14. Eye pigment isolation of *Drosophila melanogaster*.
15. Mounting of salivary gland chromosome of *Drosophila melanogaster*.
16. Immunodiffusion technique.
17.

## PS 515.3 CELLULAR BIOCHEMISTRY

**Total No. of Lectures: 42 hours** **Total marks: 70**

**No. of Lectures/week: 3** **Credits: 3**

**Course objective:**

*The course aims to provide insights into the structure and functions of biomembranes, cellular pathways, cell communication and signalling.*

*The first unit gives an extensive description of the structure and functions of biomembranes. The second unit elaborates on structural organization of cells, cell communication, and muscle contraction. The third unit explains cell signaling*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

CO 1: Outline the structure of various cellular organelles and describe the relationship between various cellular structures and their corresponding functions.

CO 2: Describe the structure and properties of biological membranes and the processes of transport across cell membranes.

CO 3: Discuss the general principles of cell communication and cell signaling.

CO 4: Describe various cellular signal transduction pathways, specifically muscle contraction.

**Unit -I** **14L**

**Biomembranes-** Physicochemical properties of biological membranes - composition, membrane asymmetry, supra molecular organization – membrane lipid phases, phase transition, function of sterols, proteins and carbohydrates, membrane protein diffusion electrical properties of membranes. Models of Membrane, Gorter and Grendel's experiment, bilayer structure, Danielle – Davson model of membrane, Singer and Nicolson's model & Newer models.

Structure of model membrane (Red blood cell), membrane domains – caveolae, rafts.

**Membrane Transport** – Laws of diffusion across membranes, simple diffusion, facilitated diffusion, osmosis and cell volume regulation. Mechanisms of endocytosis, receptor mediated endocytosis, and exocytosis, Ion channels, aquaporin channel, ionophores., Patch clamp technique, Active transport systems, ($Na^+$ $K^+$ ATPase, mammalian MDR proteins) secondary active transport ($Na^+$ glucose transporters).

**Unit -II** **14L**

**Structural organization and function of intracellular organelles:** Cell wall, nucleus, mitochondria, Golgi bodies, lysosomes, Endoplasmic reticulum, peroxisomes, plastids, vacuoles, chloroplast, structure & function of cytoskeleton and its role in motility. Mechanism of sorting & regulation of intracellular transport (nucleus, mitochondria, golgi, endoplasmic reticulum and lysosomes)

**Cellular communication-** General principles of cell communication, cell adhesion and roles of different adhesion molecules: role of adhesive glycoproteins (fibronectin),Principles of adhesion, families of adhesion receptors, cellular junctions-types, their role, extracellular matrix components. Cell – cell and Cell – matrix interaction (Integrins and selectin receptors and their interaction-Inside out signaling in endothelial cells), Bacterial chemotaxis and quorum sensing.

**Muscle Contraction** – Structure and organization of muscle cells, types of muscles - striated muscle, cardiac & smooth muscle. Molecular organization of contractile systems (actin, myosin, tropomyosin, troponin, α-actinin, nebulin, dystrophin, Molecular mechanism of contraction and relaxation of muscle - Role of calcium, troponin C, calmodulin, caldesmon, phospholamban and nitric oxide.

**Unit –III** **14L**

**Cell signalling-** Over view of cell signaling, Classes of extra cellular and intracellular receptors, Signal transduction pathways, Neurotransmission and its regulation. Biochemistry of vision, colour vision.

General mechanisms of cell signaling Receptor down regulation, desensitization and upregulation. Cytoplasmic receptors: G protein coupled receptors, β-adrenergic receptor, receptor and non receptor tyrosine kinase. Second messengers - $Ca^{+2}$, $1P_3$, DAG, cAMP & cGMP. nuclear receptor pathways: steroid hormone signaling, nitric oxide synthase-signaling

**References:**


1. Lodish, H., Berk, A., Kaiser, C. A., Kaiser, C., Krieger, M., Scott, M. P., &Matsudaira, P. (2008). Molecular cell biology. Macmillan.
2. Karp, G. (2009). Cell and molecular biology: concepts and experiments. John Wiley & Sons.
3. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., & Watson, J. D. (1993). Molecular Biology of the Cell. Third. Garland Science.
4. Cooper, G. M., & Hausman, R. E. (2004). The cell: a molecular approach.
5. Gilbert, S. F. (2017). Developmental biology, the stem cell of biological disciplines. PLoS biology, 15(12), e2003691.
6. Pollard, T. D., Earnshaw, W. C., Lippincott-Schwartz, J., & Johnson, G. (2016). Cell biology E-book. Elsevier Health Sciences.

## PS 516.3. CLINICAL BIOCHEMISTRY

**Total No. of Lectures: 42 hours** **Total marks: 70**

**No. of Lectures/week: 3** **Credits: 3**

**Course Objective:**

*This paper enables the students to understand the basic clinical biochemistry aspects that are the building blocks of life. It deals with the clinical applications of various biomolecules. The first unit elaborates on automation and quality control of clinical laboratory, body fluids and their composition, second unit on organ function tests, various blood tests and third unit on acid base balance, monitoring tests for metabolic disorders.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

**Unit-I** **14L**

CO 1: Understand the basic concepts and principles of Clinical Biochemistry, detail on the collection, preservation and storage of biological samples

CO 2: Explain principles of laboratory automation and quality control in a clinical laboratory

CO 3: Describe the different biochemical tests carried out in blood and urine for the diagnosis and prognosis of various disease conditions.

CO 4: Clinically assess the laboratory indicators of physiologic conditions and diseases

Automation in clinical biochemistry, Quality assurance, External and internal quality control measurements. Collection, transport, preservation and processing of various clinical specimens.

Body fluids: Sputum examination – Physical examination (macroscopic) and Microscopic – Gram's stain, ZiehlNeelsen stain for AFB.

Cerebrospinal fluid analysis: Physical examination (color and turbidity) Microscopic examination(total count ,differential count).

Microscopic examination of pleural, pericardial, synovial and peritonial fluid.

Semen analysis, liquefaction, volume,color,reactions,pH,motility,sperm count, morphology of sperm- importance and interpretation.

Stool examination – Macroscopic (naked eye) inspection, concentration method ,flotation method and sedimentation. Microscopic examination for parasites, Strip method, Test for Occult blood – Benzidine Test.

Urine examination, Physical, chemical and microscopic.

**Unit -II** **14L**

Liver function tests, gastric function tests, kidney function tests, pancreas function tests.

ELISA test, Widal test, VDRL test, ASLO test, Brucella Agglutination test, Weil Felix test.
Pregnancy test: Method ,interpretation advantages and disadvantages. Oral glucose tolerance test.
Blood collection, anticoagulants used in Hematology, Red blood cell indices, E.S.R., PCV, Platelet count, Absolute Eosinophil count, Reticulocyte count, Stains used in Hematology, Preparation of blood film, Peripheral smear staining by Leishman's stain. Interpretation of peripheral smear. Differential count, Osmotic fragility test, Coomb's test.

**Unit -III** **14L**

Thyroid profile tests, Fertility tests, Lipid profile tests.
Screening of metabolic disorders: Prenatal diagnosis:- AFB, hCG, PAPP-A. CT scan, MRI, X-ray, Mammography, ECG, DNA fingerprinting.
Acid –base balance: blood gas analysis, metabolic acidosis and alkalosis, respiratory acidosis and alkalosis.
Monitoring of pernicious anemia, megaloblasticanemia, hemophilia, thalassemia.

**References:**


1. Bishop, M. L., E. P. Fody, et al. (2013). Clinical Chemistry: principles, techniques, and correlations. Philadelphia, Wolters Kluwer Health/Lippincott Williams & Wilkins: xxv, 754 p.
2. Devlin, T. M. (2006). Textbook of biochemistry: with clinical correlations, Wiley-Liss.
3. Goodman, L. S., J. G. Hardman, et al. (2001). Goodman & Gilman's the pharmacological basis of therapeutics. New York, McGraw-Hill.
4. Hawk, P. B. (1954). Practical physiological chemistry. New York,, Blakiston Co.
5. Katzung, B. G., S. B. Masters, et al. (2012). Basic & clinical pharmacology. New York ; London, McGraw-Hill Medical.
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8. Vasudevan, D. M., &SreekumariS (2010).Textbook of biochemistry for medical students. Jaypee Brothers
9. Thomas M D (2011). Text book of Biochemistry, 6th Ed., John wiley publishers

## PO 517.3 EVOLUTION AND ECOLOGY

**Total No. of Lectures: 42 hours** **Total marks: 70**

**No. of Lectures/week: 3** **Credits: 3**

**Course Objective:**

*The objective of the course is to familiarize the students with the study of evolution, the processes that determine how the genetic composition of populations changes over time; the interactions between organism and their environment, among individuals within a population, and among species.*

*The first unit elaborates on the definition and theories of evolution. The second unit deals with population ecology, species and inter-species interactions. The third unit deals with the ecosystem and pollution.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

**Unit I: Evolution** **14 L**

CO 1: Discuss the scientific *theory of evolutionand*explain the points of the Modern Synthesis of evolutionary theory.

CO 2: Demonstrate broad-based knowledge of the fundamentals of Ecology, and Evolution and the relationships among these disciplines

CO 3: Describe the principal interactions between different species and how they affect the respective species.

CO 4: Discuss the biogeochemical cycles, pollution, natural resource conservation and management

Definition; Theories of Evolution – Lamarckism, Darwinism, Neo-darwinism, Modern synthesis; Evidence for evolution; Phenomena influencing evolution – Adaptation, Natural selection (genetic variation, fitness, competition), Sexual selection, Fecundity selection, Genetic drift, Gene flow, Adaptive radiation; Species concept – Definition, Parameters for the delimitation of species, Speciation: Allopatric and parapatric, Biogeography and evolutionary ecology; Evolution and development; Misconceptions and misinformation of evolution.

**Unit II : Ecology** **14 L**

Population ecology: meta-population dynamics; growth rates – density independent growth, density dependent growth; niche concept; key stone species.

Species interactions: inter-species interactions – mutualism, commensalism, competition, predation; trophic interactions; functional ecology; eco-physiology; behavioural ecology

Community ecology: Community assembly, organization and evolution; biodiversity – species richness, evenness and diversity indices; endemism; species-area relationships

**Unit III: Ecosystems** **14 L**

Ecosystems: structure and function; Aquatic ecosystem – freshwater, estuaries, marine communities; Terrestrial ecosystems. Biogeochemical cycles – gaseous, sedimentary, water, micronutrient;

Pollution: environmental pollutants – biomagnification, Pollution control; global warming and climate change.

Natural resource ecology: Natural resource conservation and management, Wild life management.

**References:**


1. Braude, S., & Low, B. S. (Eds.). (2010). An introduction to methods & models in ecology, evolution, & conservation biology. Princeton University Press.
2. Knustad, D., & Simmons, M. (2006). Principle of genetics (4th ed.). John Wiley and Sons publications.
3. Kumar, H. (2001). Text book of Cytology genetics and evolution. Kalyani Publisher, Ludhiana.
4. Life on earth: An encyclopedia of biodiversity, ecology, and evolution. (2003). Choice Reviews Online, 40(11), 40-6160-40–6160. https://doi.org/10.5860/CHOICE.40-6160
5. Mayhew, P. J. (2006). Discovering evolutionary ecology: Bringing together ecology and evolution. Oxford University Press.
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7. Purohit, S., Shammi, Q., & Agarwal, A. (2004). A text book of environmental sciences. Student Edition.
8. Verma, P., & Agarwal, V. (2004). Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. SChandPvt. Ltd., New Delhi.
9. Wright, R., &Nebel, B. (2002). Environmental Science. Prentice-Hall, India Pvt. Ltd.
10. Williams, G. (1992). Natural Selection: Domains, Levels, and Challenges (Oxford Series in Ecology and Evolution). Oxford University Press.

## PH 511.4 IMMUNOLOGY

**Total No. of Lectures: 56 hours** **Total marks: 70**

**No. of Lectures/week: 4** **Credits: 4**

**Course objective:**

*The objective of the course is to provide an insight into the various components of the immune system, their formation and development, functions and mechanisms of action as well as the diseases associated with defects or malfunctioning of the immune system.*

*This paper introduces the basic concepts of immunology in the first unit. The second unit deals with the structure and functions of immunoglobins & generation of antibody diversity. The third unit elaborates on antigen-antibody reactions, role of major histocompatibility complexes, humoral and cell-mediated immune responses.The fourth unit elaborates ontolerance vs activation of immune system and vaccines*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

CO 1: Define central immunological concepts and demonstrate basic knowledge of immunological processes at a cellular and molecular level.

CO 2: Describe the cells and organs involve in immune response and compare and contrast innate and adaptive immunity

CO 3: Elaborate on the concept of antigen, immunoglobulins and apply basic techniques for identifying antigen-antibody interactions.

CO 4: Outline key events in antigen presentation, and the cell-mediated and humoral immune responses.

CO 5: Explain the basis of immunological tolerance, autoimmunity, hypersensitive reactions, cancer immunology and principles governing vaccination.

**Unit I** **14L**

Historical perspective and Scope of immunology.

**Types of immunity**: Definition, innate, acquired- active and passive with examples. Factors affecting immunity: age, hormonal influence, nutrition.

**Mechanisms of innate immunity**: anatomical, physiological, phagocytotic and inflammatory response.

**Hematopoiesi**s: Hematopoietic growth factors, development, structure and functions of cellsof the immune system(T-cells subset of T-cells, B-cells, Natural killer cells, macrophages, antigen presenting cells, neutrophils, eosinophils, basophils, mast cells and dendritic cells).

**Organs of the Immune system**: Structure and function of Primary lymphoid organ- (Thymus and Bone marrow) and Secondary lymphoid organs- (lymph nodes, Spleen, MALT, CALT)

**Clonal selection theory** – Burnett Concept of antigen specific receptor.

**Unit II** **14L**

**Antigens:** definition, immunogens with examples, immunogenicity versus antigenicity. Types of antigens: Microbial, non-microbial, exogenous, endogenous, complete, incomplete (hapten), TD and TI(Thymus dependent and Thymus independent) antigens. Epitopes- Definition, types -sequential and spatial, properties of T-cell and B-cell epitopes, valency of antigen. Factors that influence immunogenicity. Epitope analysis.

**Immunoglobulins**: Basic structure of Immunoglobulins, Classes of Immunoglobulins, structure and functions, , isotype, allotype and idiotype variations. **Organization and expression** of immunoglobulin light and heavy chain generation of antibody diversity and T cell receptors, Antibody Class- Switching

**Immunotechnology**: Production of monoclonal antibodies, Applications of Mab – Diagnostic, therapeutic and immunopurification.

**Antigen antibody interactions**: Principles and methods of Precipitations, Agglutinations, ELISA, RIA, Immunofluorescence, Complement fixation and Flow cytometry (FACS). Measurements of T-cell activation, fraction of leukocytes on density gradient, cytotoxicity assay

**Unit III** **14L**

**Immune response**: Humoral and Cell mediated immune response.

**Kinetics** of primary and secondary immune responses.

**Major Histocompatability Complex** -Structure and functions of class I and class II MHC molecules. Polymorphism of MHC genes and HLA typing. Antigen processing and presentation- exogenous and endogenous antigens.

**Cell mediated immune response**. General properties of effector T cells. The structure and functions of T-cell receptors (TCR); the TCR-peptide-MHC tri-molecular complexes.

Cytokines and co stimulatory molecules-their role in immune response. T- & B-cell interactions; B-cell activation and proliferation by thymus independent and thymus dependant antigens.

**Complement System**: General Properties, components, complement activation, Classical, alternate pathway and Lectin pathway.

**Unit IV** **14L**

**Tolerance Vs Activation of immune system:** Immune tolerance, hyper sensitivity reactions (Type I, II, III and IV).

**Immune Responses to infectious diseases**: bacterial, viral and protozoan

**Immunodeficiency disorders**- Primary and Secondary-SCID, AIDS

**Auto immunity**: Classification and mechanisms of autoimmune diseases- Insulin Dependent Diabetes Mellitus, Rheumatoid Arthritis, Thyroid disease

**Cancer and Immune system**: Tumor antigens (Tumor associated antigens and Tumor specific antigens), Factors favoringtumor growth, immune surveillance. Immunotherapy of malignancy.

**Vaccines:** Active and Passive immunization, types of vaccines. Herd Immunity

**REFERENCES:**


1. Kindt, T. J., Goldsby, R. A., Osborne, B. A., &Kuby, J. (2007). *Kuby immunology*. Macmillan..
2. Edition, I. S. Immunology 7th Ed.-D. Male, J. Brostoff, D. Roth, I. Roitt (elsevier, 2006).
3. Abbas, A. K., Lichtman, A. H., & Pillai, S. (2019). *Basic Immunology E-Book: Functions and Disorders of the Immune System*. Elsevier Health Sciences..
4. William L. Anderson (1999), Basic Principles of Immunology, Fence Creek Publishing (Blackwell).
5. Dulsy Fatima and, N Arumugam (2014)., Immunobiology, Sara publication.
6. Stites, D. P., Stobo, J. D., & Wells, J. V. (1987). *Basic & clinical immunology*. Appleton & Lange.

## PH 512.4. GENETICS

**Total No. of Lectures: 56 hours** **Total marks: 70**

**No. of Lectures/week: 3** **Credits : 4**

**Course Objective :**

*The objective of this course to provide knowledge about the structure and function of nucleic acids, basic processes that regulate expression of genetic information, biological processes that direct inheritance of genetic information, and an overview of cancer genetics*

*The first unit deals with basic principles of Mendelism and population genetics. The second unit discusses the genome organization, gene linkage and mapping of the genes. The third unit deals with mutations and DNA repair mechanism and also discusses some hereditary diseases. The fourth unit deals with cancer genetics*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

**Unit-I** **12L**

CO 1: Describe basic concepts of classical Genetics, Mendelian inheritance, extrachromosomal inheritance, sex-linked inheritance and population genetics

CO 2: Elaborate on the concept of gene, genome organization, linkage and genetic mapping and recombination.

CO 3: Discuss the different organisms used as models for studies in genetics

CO 4: Comparing and contrasting different mutation and DNA repair mechanisms and relate variations in chromosome structure and number to phenotypic variation.

CO 5: Describe the relationship between cell cycle and cancer and summarize the mechanism of transformation of cells

Classical genetics – Mendelian principles: dominance, segregation, independent assortment, deviation from Mendelian inheritance.

Extensions of Mendelian principles - incomplete dominance, codominance, epistasis, simple gene interaction (eg. Comb shape in chickens), polygenic inheritance, penetrance and expressivity, sex limited and sex influenced characters.

Extra chromosomal inheritance: Inheritance of mitochondria (e.g. Male sterility in plants), and chloroplast genes (e.g. Variegation in four O'clock plant), maternal inheritance (e.g. Shell Coiling in snails).

Population Genetics: Speciation (allopatricity and sympatricity). Hardy Weinberg genetic equilibrium, random genetic drift, coevolution, convergent evolution, Pedigree analysis,

**Unit-II** **20L**

Genome size and evolutionary complexity, C-value paradox

Structure of bacterial chromosome, structure of eukaryotic chromosome, nucleosome organization, arrangement of chromatin fibers in a chromosome.Polytene chromosomes, centromere and telomere structure.

Concept of gene: Allele, multiple alleles, pseudo allele, complementation tests.Transposons and their types

Gene Linkage and Chromosome – Linkage and crossing over, sex linkage, linkage, recombination of genes in a chromosome, crossing over, map unit.

Gene mapping methods: Linkage maps, three-point test cross, tetrad analysis, mapping by using somatic cell hybrids, development of mapping population in plants.

Recombination-types – homologous, site-specific, somatic recombination. E.coli rec system. Holliday model of recombination.

Microbial genetics: Methods of genetic transfers – transformation, conjugation, transduction and sex-duction, plaque formation and lytic cycle

**Unit-III**

**Mutation and Cancer** **10L**

Models for genetic studies: Rat/Mice, Drosophila, yeast, Arabidopsis thaliana, zebra fish and E.coli.

Mutation– Types, causes and detection, mutant types – lethal, conditional, biochemical, loss of function, gain of function, germinal verses somatic mutants. Mutation rates. Chemical mutagens-affecting replicating & non-replicating DNA, radiation induced mutation, reverse mutations and suppressor mutations – intergenic and intragenic suppression, reversion as a means of detecting mutagens – Ames test.

Repair Mechanism – photoreactivation, excision repair, repair of alkylation, E.coli- rec system (SOS repair).

Chromosomal abnormalities: Deletion, duplication, inversion, translocation, ploidy and their genetic implications. Human genetics: lod score for linkage testing, karyotypes, Genetic counselling.

**Unit-IV** **14L**

**Cancer**

Cancer and the cell cycle, types of cancer, differences between normal and cancer cells-Warburg effect, interaction of cancer cells with normal cells, contact inhibition, loss of cellular affinity, alterations in cytoskeleton, cell surface, decreased serum requirements and secretion of growth factors.

Mechanism of transformation of cells. Cellular oncogenes - Oncogene families: Protein kinases (Src, ablerbBI), GTP binding proteins (H-ras, K-ras), growth factors (sis), nuclear proteins (myc,fos), hormone receptors (erbA) and unclassified. Proto-oncogenes-activation to oncogenes, and Retroviral oncogenes (v-src, v-sis v-erbA or v-erbB v-kras v-mos). Tumor suppressor genes-their role in cell cycle control and tumor development (RB, p53, p16, p21,PTEN), Telomerases and their role in cancer. metastasis, therapeutic interventions of uncontrolled cell growth.

**References**


1. Dale, J. W., & Park, S. F. (2013). Molecular genetics of bacteria. John Wiley & Sons..
2. Hartl, D. L. (2014). Essential Genetics: A Genomics Perspective: A Genomics Perspective (6th ed.). Jones & Bartlett Learning.
3. Hartl, D. L., & Jones, E. (2001). Genetics: Analysis Of Genes And Genomes (5th ed.). Jones & Bartlett, Boston.
4. Klug, W. S., Cummings, M. R., Spencer, C. A., & Palladino, M. A. (2011). Concepts of Genetics (10th ed.). Pearson Education.
5. Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2012). Lewin's Essential GENES (Biological Science) (3rd ed.). Jones & Bartlett Learning.
6. Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2017). Lewin's GENES XII (12th ed.). Jones & Bartlett Learning.
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8. Pierce, B. A. (2013). Genetics: A Conceptual Approach, 5th Edition (4th ed.). W. H. Freeman.
9. Snustad, P. D., & Simmons, M. J. (2006). Principles of Genetics (4th ed.). Wiley.
10. Snyder, L., Peters, J. E., Henkin, T. M., &Champness, W. (2013). Molecular Genetics of Bacteria, 4th Edition (ASM Books) (4th ed.). ASM Press.
11. Watson, J. D. (2003). Molecular Biology of the Gene (5th ed.). Cold Spring Harbor Laboratory Press.

## PH 513.4P PROJECT WORK

**Total marks: 70**

**No. of practical/week: 10 hours** **Credits: 5**

**Objective:**

*The objective of this course is to enable the students to acquire skills through training in several research methods, tools, techniques, literature review and report writing associated with their dissertation research area in the mentorship of a specific faculty for personal attention and systematic learning.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

CO 1: Demonstrate and understanding on the scope of research in their assigned dissertation research topic, troubleshoot, and successfully outline the aims and objectives for subsequent dissertation work.

CO 2: Critically review literature, find gaps in research, select a research problem/ test hypothesis and design experiments.

CO 3: Perform experiments, collect data, draw conclusions and interpret the results and discuss the work in the light of work previously done by other researchers.

CO 4: Communicate in oral and written form by integrating data and interpretation and relate to the concept of ethics in research

Students can take up research project work under the guidance of faculty in any area of the prescribed syllabus. They can also opt to go to other institutions during the summer vacations after second semester. In the former, students are allotted guides and, in the latter, they can choose the institution of their choice and make arrangements for the same, however an internal guide will be assigned to the student. Guidelines for the preparation, presentation and evaluation of student research projects is provided in Annexure-I.

## PS 514.4 GENETIC ENGINEERING AND BIOINFORMATICS

**Total No. of Lectures: 42 hours** **Total marks: 70**

**No. of Lectures/week: 3** **Credits: 3**

**Objective:**

*The objective of the course is to introduce the students to basic concepts in genetic engineering and familiarize them to the versatile tools and techniques employed in genetic engineering and recombinant DNA technology. The course also aims at introducing the basic concepts in Bioinformatics.*

*The first unit deals with enzymes and vectors used in molecular cloning. The second unit elaborates genomics, proteomics and the techniques for introduction of genes and selection of recombinants and hybridization techniques. The third unit deals with Bioinformatics.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

CO 1: Acquire knowledge about the advances in modification, and recombination of DNA or other nucleic acid molecules to modify an organism.

CO 2: Enlist the vectors used in *genetic engineering* and discus their application

CO 3: Discuss tools and techniques of genetic engineering like transformation, hybridization, transcriptomeanalysis, sequencing and more.

CO 4: Describe and use the biological databases, perform structured query, data retrieval and analyse and discuss the results

**Unit I** **12 L**

**Tools in Genetic Engineering**

Enzymes: DNA-dependent DNA polymerases – thermostable polymerases, proofreading activity; RNA-dependent DNA polymerase; Ligases – DNA and RNA ligases; Phosphatases and Kinases; Nucleases – Deoxyribonucleases and ribonucleases, exonucleases, endonucleases and restriction endonucleases; methylases; topoisomerases – TOPO® cloning method; CRISPR-Cas9.

Vectors: Types of vectors – cloning and expression, prokaryotic and eukaryotic; Features of vectors – cloning and expression, prokaryotic and eukaryotic; Shuttle vectors; hybrid

vectors; Descriptions of some vectors – Plasmids, viral vectors, cosmids and artificial chromosomes; inducible vectors; fusion vectors.

Hosts and Expression systems: Bacterial – *Escherchia coli*; Yeast – *Saccharomyces cerevisiae*, *Pichia pastoris*; Insect cell lines – *Spodopterafrugiperda* Sf-9, *Trichoplusiani* BTI-TN-5B1-4; Plants – *Arabidopsis thaliana*, *Nicotianabenthamiana*; Mammalian cell lines – Chinese Hamster Ovary (CHO), COS, Human Embryonic Kidney (HEK), HeLa. Advantages and disadvantages of different expression systems.

**Unit II** **20 L**

**Genes and Genomics**

Genomic library; cDNA library; transformation – calcium phosphate method, DEAE-Dextran method, Liposome mediated transfer, microinjection, electroporation, biolistic methods; Screening – insertional inactivation of marker gene, replica plating, visual screening; DNA probes – preparation of probes, plaque hybridization, FISH, Southern blot, colony hybridization, dot blot; DNA sequencing – Sanger Sequencing, Pyrosequencing, Illumina sequencing, Sequencing by Oligonucleotide Ligation and Detection (SOLiD); Restriction mapping; Polymerase chain reaction – standard PCR, quantitative PCR.

**Proteins and Proteomics**

Edman degradation; yeast one-hybrid assay, two-hybrid assay; ELISA; western blot or immunoblot; protein microarrays; mass spectrometry and protein profiling; *in vitro*mutagenesis; site-directed mutagenesis – subtilisin; filter binding assay; gel mobility shift assay; DNase foot printing; Chromatin immunoprecipitation.

**mRNA and Transcriptomics**

Northern blot; *in situ* hybridization; Serial analysis of gene expression (SAGE); trancriptional mapping; RNAi analysis; reverse transcriptase-PCR; DNA microarrays; RNA-seq; gene set enrichment analysis; detection and analyisis.

**Techniques to study Genomics--** Tools of positional cloning; RAPD, RFLP, Exon trapping, CpG Islands (HTF islands) Genome Sequencing methods- clone-by clone strategy- role of VNTRs, sequence-tagged site, microsatellites, & expressed sequence tag. Radiation hybrid mapping, shotgun sequencing. Human genome project –strategy adopted & major findings. Chromosome walking & jumping- method & application. Proteomics- 2D electrophoresis, phage display, microarray as tools to study.

**Unit - III** **10L**

**Bioinformatics**:

**Bioinformatics and Data Bases:** Definitions, scope and application of bioinformatics.

**Databases:** Definition and classification. Database management public agencies- NCBI, EBI. Gen Bank Sequence database. Protein databases: SWISSPROT, PIR, Pfam and signal peptide databases.

**Structural analysis:** ProteinStructural databases – PDB, MMDB; Tools and approaches for protein structural analysis, Tools for structural viewing – RasMol.

**Sequence alignment and applications** Homology, concept and alignment of pairs of sequence, Global & Local Alignment, Basic Local Alignment Search Tool (BLAST). Multiple sequence alignment – tools (Clustal omega) and its applications.

**Molecular phylogenetics:** Introduction, application of phylogenetic trees, basic terminology, taxa, root, leaf, node, tree, branch, clade, dendrogram, cladogram, rooted tree, unrooted tree. Phylip.

**References:**


1. Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2017). Lewin's genes XII. Jones & Bartlett Learning.
2. Primrose, Sandy B., and Richard Twyman. Principles of gene manipulation and genomics. John Wiley & Sons, 2013.
3. Tropp, B. E. (2012). Molecular biology: genes to proteins. Jones & Bartlett Publishers.
4. Brown, T. A. (2020). Gene cloning and DNA analysis: an introduction. Wiley-blackwell.
5. Winnacker, E. L. (2003). From Genes to clones–Introduction to Gene technology. Indian Reprint
6. Heslot, H. (2018). Molecular biology and genetic engineering of yeasts. CRC Press.
7. Gibson, W., & Koch, C. (2019). Biotechnology and Genetic Engineering. Scientific e-Resources.
8. Nicholl, D. S. (2008). An introduction to genetic engineering. Cambridge University Press.
9. Rastogi, S. C., Rastogi, P., &Mendiratta, N. (2008). Bioinformatics Methods And Applications: Genomics Proteomics And Drug Discovery 3Rd Ed. PHI Learning Pvt.Ltd..
10. Baxevanis, A. D., Bader, G. D., & Wishart, D. S. (Eds.). (2020). Bioinformatics. John Wiley & Sons

## PS 514.4 CLINICAL TOXICOLOGY

**Total No. of Lectures: 42 hours** **Total marks: 70**

**No. of Lectures/week: 3** **Credits: 3**

**Course objective:**

*The objective of this course is to acquaint students with various aspects of toxicology, organ toxicity, dosage effect and its mechanism of action.*

*The first unit deals on the role of good laboratory practices, evaluation of toxicity and QC & various standards in clinical lab. The second unit deals with organ toxicity and common antidotes and metabolism of toxicants. The third unit deals with systemic pharmacology and drugs used for various diseases.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

**Unit I** **10L**

CO 1: Describe the general principles of clinical toxicology and discuss factors that influence toxicity.

CO 2: Explain the basics of pharmacodynamics, pharmacokinetics and PK/PD correlation.

CO 3: Recognize system-specific and organ-specific toxic effects and discuss metabolism of toxicants

CO 4: Describe pharmacological actions, uses & adverse effects of drugs

**Introduction to clinical toxicology:** definition, sources of drugs & routes of drugs administration.

**Basics of pharmacodynamics, pharmacokinetics, PK/PD correlation, Calculation of Pharmacokinetics (clearance)**

**Drug delivery systems**: sustained release, enteric coated formulations liposome, microinjections and nanoparticles.

**Dose-response relationships:** threshold dose, no observed effect level (NOEL), measurement of cumulative effects- time relationship. Therapeutic index, Calculation of LD50 & ED50. The area under the curve (AUC)of the concentration-time profiles, absolute bioavailability, Volume of Distribution (Vd),maximum tolerated dose (MTD).

New drug development process and drugs registration.

**Evaluation of toxicity**- Selection of organisms, Preclinical toxicological studies,(Acute, sub-acute and chronic toxicity studies). Irwin profile test. Lipinski's rule of FIVE.

**Clinical Trials**: Clinical evaluation of new drug, phases of clinical trial, ethics and protocol.

**Unit II** **20L**

**Organ toxicity:**

**Hepatotoxicity**: mechanism of hepatoxicity caused by carbon tetrachloride.
**Nephrotoxocity**: metals-cadmium, lead, mercury, uranium.

**Neurotoxicity**: mechanism- alteration in synaptic function: organophosphates.

**Endocrine toxicants**: Organizational versus Activational Effects of Endocrine Toxicants.

**Respiratory system toxicants-** types of toxic responses (irritation, cell necrosis, Fibrosis, Emphysema, Allergic Responses, Cancer)

**Antidotal therapy**: types of antidotes: universal, simple & multiple antidotes: definition & examples. Antidotal procedures: decrease absorption of toxicants: By emetics and chelating agents. Termination of action of toxicants: diuresis & dialysis. Methods to elevate threshold of toxicity.

**Metabolism of toxicants:** Different phases of detoxification- Phase I- The Cytochrome P450-Dependent Monooxygenase System**,** flavin-containing monooxygenases (FMO).
Phase II-Conjugation reactions: glucoronide conjugation, glutathione-S-transferases.

**Elimination of Toxicants** - renal, hepatic & respiratory elimination.

**Unit III**

**Pharmacological actions (MOA), uses & adverse effects of:** **12L**

**CNS drugs** – Sedative Hypnotics -

**Opioids -** morphine, codeine.

**Drugs of abuse**: Alcohol, , cocaine, LSD, GHB, tobacco, nicotine.

**Respiratory: drugs:** : salbutamol & montelukast.

**GIT disorders**: anti-emetics: metoclopramide, Drugs in peptic ulcer: cimetidine.
Diuretics : chlorothiazide

**Cardiovascular drugs**: in heart failure: digoxin,

**Vasodilators**: nitroglycerine.

**NSAIDS**: paracetamol, aspirin.

**Anabolic steroids**: estradiol, methyltestosterone, dexamethasone.

**Antimicrobial agents**: isoniazid, amphotericin B, acyclovir, and chloroquine.

**Anti-cancer agents**: cyclophosphamide, mercaptopurine, vinblastine, vincristine.

**References:**


1. Tripathi, K. D. (2013). Essentials of medical pharmacology. JP Medical Ltd.
2. Hodgson, E. (Ed.). (2004). A textbook of modern toxicology. John Wiley & Sons.
3. Omkar. (2014). Concepts of toxicology. Vishal Publishers.
4. Thomas, L. (6th Ed), (2008). Foyes principles of medicinal chemistry. WolterKlu Publishers.
5. Joel, G. Lim. (10th Ed). (2001). Goodman and Gilman pharmacological chemistry. Tata McGrawhill.
6. Richard, C. (2004). Medical toxicology. Lippincott.
7. Curtis, D. (6th Ed). (2001). Casarett and Doull's toxicology. Oxford University Press.

## PS 516.4 FOOD BIOCHEMISTRY

**Total No. of Lectures: 42 hours** **Total marks:70**

**No. of Lectures/week: 3** **Credits : 3**

**Course Objective:**

*The objective of this course is to provide exposure to the students of basic concept of food, nutrients, nutraceutical's and food microbiology*

*The first unit deals with the basic properties of water, protein, carbohydrate, lipids, minerals, vitamins, and phytochemicals and their roles in food systems. The second unit introduces the concept of nutraceuticals and their role in disease treatment and prevention. The third unit elaborates on the aspects of food microbiology, their applications and harmful effects.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

CO 1: Discuss the concept of food and nutrition

CO 2: Enlist macro- and micronutrients, their sources and functions in the human body.

CO 3: Explain the concept of nutraceuticals and their role in treatment and prevention of various disease conditions

CO 4: Discuss the biochemical changes caused by microorganisms in context of fermented food and food spoilage

**Unit I** **14L**

Basic food biochemistry: basic concept of food, nutrients, nutrition

Classification of food constituents; Carbohydrates- sources, daily requirements, functions. chemical reactions, functional properties of sugars and polysaccharides, modified starch, dietary fibre.

Lipids- estimation and physiochemical properties of lipids in food, rancidity, hydrogenation and winterization, vegetable and animal fat, margarine, lad and butters.

Protein-classification and properties, egg proteins, milk proteins,meat proteins, oil seed proteins and cereal proteins.

Vitamins and minerals- role, effect of various processing treatments, fortification.

Role of water in food, water activity and shelf life of food. significance of natural pigments in food- chlorophylls, carotenoids, anthocyanins, flavonoids and tannins, natural antioxidants, Browning reactions in foods.

**Unit II** **14L**

Nutraceuticals

Introduction to nutraceuticals: definitions, synonymous terms, basis of claims for a compound as a nutraceutical, regulatory issues for nutraceuticals including CODEX. Nutraceuticals for cardiovascular diseases, cancer, diabetes, cholesterol management, obesity, joint pain, immune enhancement, age-related macular degeneration, endurance performance and mood disorders.

Manufacturing aspects of selected nutraceuticals such as lycopene, isoflavonoids, prebiotics and probiotics, glucosamine, phytosterols.

**Unit III** **14L**

Growth and survival of microorganisms in foods; spoilage organisms of milk, fruits, vegetables, grains and oilseeds, meat and poultry; Food poisoning and food borne infections; Microbial toxins. Physical and chemical methods to control microorganisms

Biochemical changes caused by microorganisms; Microbes in food fermentation, Fermented foods based on milk, meat and vegetables; Fermented beverages, Traditional fermented foods of India and other Asian countries; Probiotics and prebiotics; Food hygiene and sanitization: Contamination during handling and processing and its control; indicator organisms; Rapid methods in detection of microorganisms.

**References**


1. Aluko, R. E. (2012). Functional Foods and Nutraceuticals. Springer.
2. Beuchat, L. R., Montville, T. J., & Doyle, M. P. (2001). Food Microbiology: Fundamentals and Frontiers (2 ed.). ASM Press, Washington DC.
3. Choudhary, A. K. (2014). Food analysis. Anmol Publications.
4. Fennema, O. R. (n.d.). Principles of Food Science: part I (2nd ed.). Marcel Dekkar Inc.
5. Furia, T. E. (1980). Handbook of food additives (Vols. 1 & 2). Press bocraton, FL.
6. Jay, J. M. (2009). Modern Food Microbiology (3rd ed.). VNR, New York.
7. Meyer, L. M. (2013). Food Chemistry (1st ed.). CBS publisher, New Delhi.
8. Sinha, S. K. (2012). Food Microbiology. Oxford University Press.
9. Stanbury, P. F., & Whitaker, A. (2005). Principles of Fermentation Technology (2nd ed.). Indian edition.

**PS 517.4P Methods in Genetic Engineering and Bioinformatics**

**Total marks: 70**

**No. of practical/week: 8 hours** **Credits :3**

**Course objective:**

*The objective of this practical course is to provide hands-on-experience to students with techniques involved in* manipulation *and analysis of genomic sequences.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

CO 1: Learn to use tools and techniques in genetic engineering

CO 2: Demonstrate and explain transformation techniques and selection of transformants

CO 3: Perform biological database search, retrieve data and analyse the data employing various bioinformatics tools

1. Restriction digestion & Ligation of DNA Agarose gel electrophoresis
2. Calcium chloride mediated transformation of *E.coli*& Selection of transformants
3. Genetics -problems
4. Restriction mapping
5. Karyotyping
6. PCR
7. Sequence Databases
8. BLAST
9. Multiple sequences alignment
10. Preparation of phylogenic tree
11. Primer designing
12. Structural Database-RasMol

## PS 518.4P EXPERIMENTS IN FOOD SCIENCE

**Total marks:70**

**Practical:8hr/wk** **Credits :3**

**Objective:**

*The objective of this practical course is to provide students with practical abilities required to work in the food industry, research centres, and food-related national and international organizations.*

**Course Learning Outcomes:** Upon completion of this course, students will be able to

1. Determination of antinutritional factors in foods.

CO 1: Explain principles behind analytical techniques associated with food.

CO 2: Perform various food analysis techniques and interpret the results

CO 3: Identify the biochemical component of various foods and assess the nutritive value of food sample.

2. Determination of thermal inactivation time of enzymes
3. Lycopene extraction from tomato peel
4. Preparation of sauerkraut
5. Determination of quality of egg by brine flotation technique
6. Quantitative estimation of acidity of milk by titration method
7. Determination of Brix: acid ratio of fruits and vegetables
8. Browning in fruits and vegetables
9. Effect of sugar on boiling point of water
10. Estimation of benzoic acid in food samples
11. Determination of nitrates and nitrites in foods
12. Determination of gluten content in wheat flour
13. Estimation of curcumin content of turmeric
14. Estimation and fat and SNF in milk

**********

**Annexure-I**

## Guidelines for the preparation, presentation and evaluation of students research projects of IV semester

### Preamble

Research based learning has become an integral part of education at higher level. Autonomy provided to the college has created opportunities for introducing innovativeness through effective learning. In this regard, the choice-based credit system introduced to postgraduate programmes from the year 2016-17 has introduced the concept of project work in the fourth semester for four credits.

Research projects play an important role in the curriculum, wherein students develop a research culture by going through the published research articles, documents, choosing a relevant problem, preparing and collecting relevant materials/samples, analyzing and characterising them to arrive at their own findings and conclusions. It is a work that a student must do largely under his / her own direction, in the field of the chosen area, however faculty members will extend their help and guidance towards the implementation of the project work.

This guideline describes the procedures to be followed in the due course of implementation of the project. It outlines the general rules and regulations which govern the project, in terms of research work both theoretical and experimental, preparation of thesis and presentation/publication.

### Planning the Project Work

The Students are advised to begin choosing relevant area of their interest during the third semester itself. However by the end of third semester he/she should meet the Head of the department with few project plans of his choice in the order of priority.

### Allotment of the Project Work

By the end of third semester, the Head of the department in consultation with other members of his/her department, study the feasibility of the student's proposal in terms of materials(chemicals), facility, space and cost effectiveness, expertise in the relevant area etc. and allot a group of students to a particular project and a supervisor. By and large student's selected area is allotted without any bias.

### The Role of Supervisor

The supervisor will able to advise the student about all aspects of the project as it unfolds. He/she must able to foresee the relevance, applicability and its uniqueness. He will constantly monitor the progress and the quality of the work and give appropriate direction as and when it demands through his/her availability in the department/Lab. He/she also make the student aware of inadequate progress or any other facts which could impede the completion of a successful piece of work.

**Responsibilities of the Student**

A student should spend a minimum of 8 hours for the project in the library by referring the articles or in laboratory by doing the experimental work in a week throughout the fourth semester. Student should try to keep supervisor informed about progress and plans in respect of project. To make appointments with the supervisor on a regular basis, if he / she is facing difficulty in arranging appointments he /she must contact the Head of Department.

Student should submit at least two written progress reports prior to the presentation in the department. Students should accept the constructive criticism of the supervisor in the point of improving the quality of research work of his/her project.

Format of the thesis/report is attached at the end

**Award of Internal assessment marks (out of 30)**

1. Action plan: Review of literature/ plan of work/ Synopsis**: 10 marks**
2. Actual work, results, interactions and regular submission of reports**: 10 marks**
3. Presentation in front of all members of the department before preparing the final thesis; ( The faculty members may fine tune or give suggestions to improve the quality of final work at this stage): **10 marks**

**External examination**

External examination will be conducted in a similar manner to practical examinations. A group of 10-12 students allotted to a batch. One internal and one external examiner approved by Board of studies of the concern department will conduct *viva-voce.* The marks are distributed as follows (out of 70)

- Thesis (report) content: **45 marks**

(45 marks are split into 40+5; Out of 45 marks, 3 marks are allotted to the student, who present the paper in any conference and the remaining 2 marks are allotted for the student if he/she wins a prize in the paper presentation.

- Presentation in the final examination: **15 marks**
- Viva-voce:**10 marks**

Student should prepare one or two (if demanded by the department) copies of the report which he/she can preserve for themselves after the final *viva-voce*.

Note: Due to lack space to keep bound copies of the project reports, the department may instruct the students to submit the department (library) copy of the project report in compact disc (CD) form. However good projects (at least 3 to 5 in a year) which are worth referring can be preserved in the bound copy form in the department. The same can be used to present before committees (NAAC, DST, LIC etc.) at the time of inspection. This can be told to students in their pre-*viva* presentation (presentation in the department).

**Project Report Format**

COVER PAGE (AS PROVIDED)

FRONT PAGE (AS PROVIDED)

CERTIFICATE (AS PROVIDED)

ACKNOWLEDGEMENT

DECLARATION (AS PROVIDED)

CONTENTS

1. INTRODUCTION
2. REVIEW OF LITERATURE
3. AIM AND OBJECTIVES
4. METHODOLOGY / EXPERIMENTATION / MATERIALS & METHODS
5. RESULTS and DISCUSSION
6. CONCLUSIONS
7. REFERENCES
8. Certificate for Plagiarism check

- **INTRODUCTION**: This includes the background of the work, lacuna if any in previous work and importance of the present work. The last part of introduction

must highlight the objectives. The objectives should give a clear picture of the project.

- **REVIEW OF LITERATURE**: Includes the study and experimentation carried out by other workers on the topic which is being studied in the present project. The subheadings may be given at appropriate places for covering the topic under consideration. The subheadings may be appropriately numbered, eg, 2.1, 2.1.1 2.2, etc. The literature must be cited with suitable references e.g. (Subbiah *et al.,* 2005), ( Ravi and Harish 2009) etc.
- **MATERIALS AND METHODS**: The write -up must include the Materials used for the project work. Brand names of equipments and chemicals need to be specified. The methodology must be described briefly (the main principle involved is sufficient) citing the reference from which it is based. Only if the method is new, give detailed explanation.
- **RESULTS AND DISCUSSIONS**: This chapter must include the results of the project developed. The results must be depicted as figure, tables, graphs etc. Also the results must be explained in words. The comparison of the results, statisitical significance of the results should be discussed in this chapter. The concluding remarks may be included specifying how the project can help the end user.
- **CONCLUSIONS:**This includes the end result derived from the project and any further scope of research which can be carried out using the present work.
- **REFERENCES:** At the end of the report 30 to 50 references relevant to the topic chosen should be given. The style of reference can be chosen according to any good international journal of the concern PG program. It is left to the desecretion of the department.

**<u>Examples to write the references</u>**

**BOOKS with an author**

Author's surname, initials. (full stop)Year. (in brackets) (full stop) Title of book. (underlined OR italics) (full stop) Publisher, (comma) Place of publication. (full stop)

Eg: Smith, P. (1999). How to write good assignments.Penguin Books, Ringwood.

**BOOKS with an editor**

Editor's surname, initials. (full stop) (ed.) (in brackets) Year. (in brackets) (full stop) Title of book. (underlined OR italics) (full stop) Publisher, (comma) Place of publication. (full stop)

Eg: Mawson, S. (ed.) (2001). Easy assignment writing. Doubleday Books, Sydney

**CHAPTER IN AN EDITED BOOK**

Chapter author's surname, initials. (full stop) Year. (brackets) (full stop) Title of chapter. (full stop) Followed by In: (underlined) (colon) Editor's surname, initials. (full stop) (ed.) (in brackets) Title of book. (underlined OR italics) (full stop) Publisher, (comma) Place of publication. (full stop)

Eg: Woods, K. (2002). Dog grooming for beginners. In: Jolley, R. (ed.) Pets are people. Harper Collins, Melbourne.

**JOURNAL ARTICLES**

Author's surname, initials (full stop) Year. (in brackets) (full stop) Title of the article. (full stop) Title of the journal. (underlined OR italics) (full stop) Volume, number, month/season, (comma) Page number of article. (full stop)

1. Eg; Byrne, P. (1992).All about friends.The Journal of Relationships.No.12, December, pp1-13.
2. Jagetia GC, Reddy TK. The grape fruit flavonoid naringinprotectsagainst the radiation induced genomic instability in the mice bone marrow: a micronucleus study. Mutation research 2002;519(2):37-46. (Biochemistry/ Biotechnology )
3. M. Dutta, S. Mridha, D. Basak, Appl. Surf. Sci. 254 (2008) 2743.(Physics)
4. Y. He, P. Sharma, K. Biswas, E. Z. Liu, N. Ohtsu, A. Inoue, Y. Inada, M. Nomura, J. S. Tse, S. Yin, and J. Z. Jiang, Phys. Rev. B 78, 155202 (2008). (Physics)

**WORLD WIDE WEB**

Author's surname, initials. (full stop)Year. (in brackets) (full stop) Title (underlined OR italics) [Internet]. [in square brackets] (full stop) Publisher, (comma) Place of publication. (full stop) Available from: <URL> [accessed date].

Eg: Holland, M. (1996). Harvard System [Internet].Bournemouth University, Poole. Available from: http://www.bournemouth.ac.uk/library/using/harvard_system.html [Accessed 1 November 2004].

**Note:**

Good quality white executive bond paper A4 size should be used for typing and duplication. Care should be taken to avoid smudging while duplicating the copies.

**The text of the contents: Times new roman font-12, line spacing 1.5**

Page Specification:

Left margin - 3.0 cm

Right margin- 2.0 cm

Top margin- 2.54cm

Bottom margin 2.54 cm

**Page numbers** - All text pages should be numbered at the bottom center of the pages.

**Normal Body Text: Font Size**: 12, Times New Roman, 1.5 Spacing, Justified. 6 point above and below para spacing

**Paragraph Heading Font Size:** 14, Times New Roman, Left Aligned. 12 point above & below spacing.

**Chapter Heading Font Size:** 16, Times New Roman, Centre Aligned, 30 point above and below spacing.

COVER PAGE

**TITLE**

(Times New Roman, Font 20, Capitals, Bold)

A Project Report

Submitted by

(Times New Roman, Font 12)

**NAME**

(**REG.NO.**)

(Times New Roman, Font 12, Bold, Capital)

to

**ST. ALOYSIUS COLLEGE,** (AUTONOMOUS)

(Times New Roman, Font 20, Bold, Capital)

(Times New Roman, Font 12, Capital)

In part fulfilment of the requirements for the award of

**Master of Science**

(Times New Roman, Font 16,)

**DEPARTMENT NAME**

(Times New Roman, Font 16,Capital,)

**Department of PG Studies and Research in Department Name**

(Times New Roman, Font 16)

April, 2020

(Times New Roman, Font 16)

FRONT PAGE

**TITLE**

(Times New Roman, Font 20, Capitals, Bold)

A Project Report

Submitted by

(Times New Roman, Font 12)

**NAME**

(**REG.NO.**)

(Times New Roman, Font 12, Bold, Capital)

Under the guidance of

(Times New Roman, Font 12)

**GUIDE NAME**

(Times New Roman, Font 12, Bold, Capital)

to

**ST. ALOYSIUS COLLEGE** (AUTONOMOUS)

(Times New Roman, Font 20, Bold, Capital)

(Times New Roman, Font 12, Capital)

In part fulfilment of the requirements for the award of

**Master of Science**

(Times New Roman, Font 16,)

**DEPARTMENT NAME**

(Times New Roman, Font 16,Capital,)

**Department of PG Studies and Research in Department Name**

(Times New Roman, Font 16)

April, 2020

(Times New Roman, Font 16)

## CERTIFICATE

This is to certify that the project report entitled "----------**Title----------**" is a bonafide work carried out by ----------**Name----------**, ----**Reg.No.----** under theguidance of ---------**GuideName--------** in the Department of PG Studies in Department Name and Research, St. Aloysius College(Autonomous), Mangaluru.

The same is being submitted to the Post Graduation Department of Department Name, St. Aloysius College(Autonomous), Mangaluru in partial fulfilment of the requirements for the award of **Master of Science-Department Name** . No part of this thesis has been presented for the award of any other degree.

Name & Signature of HOD

Name & Signature of the Guide

## ACKNOWLEDGEMENT

In the "Acknowledgement" page, the writer recognizes his/her indebtedness for guidance and assistance of the different persons and members of the faculty. Courtesy demands that he/she also recognize specific contributions by other persons or institutions such as libraries and research foundations/funding agencies. Acknowledgements should be expressed simply, tastefully, and tactfully.

## DECLARATION

I/, ------**Name**-------- hereby declare that the project work entitled "**----------Title----------**" is my original work and has been carried out under the guidance of **----------Guide Name----------, PG Department of Department Name, St. Aloysius college(Autonomous), Mangaluru** is being submitted to the **Department of PG Studies and Research in Department Name, St. Aloysius college(Autonomous), Mangaluru** in partial fulfilment of the requirements for the award of **Master of Science-Department Name** .

I also hereby declare that this work, in part or full, has not been submitted to any other University/Institution for any Degree/Diploma.

Date of Submission: Signature of the candidate

NAME

(REG.NO.)

Signature of the Guide

NAME

**********