**Kurukshetra University Kurukshetra**

**Syllabus and Scheme of Examination for M.Sc. (Integrated) Biotechnology**

**Under**

**Choice Based Credit System (CBCS) w.e.f. 2020-21(in phased manner)**

**Subject: Biotechnology**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Semester** | **Course** | **Paper** | **Nomenclature of paper** | **Credits** | **Workload/week****(hr)** | **Internal marks** | **External Marks** | **Total** | **Exam Time (hrs)** |
| **1** | CC-1 | IN-BTY-101 | Biomolecules | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY-102 | Biomolecules - Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| CC-2 | IN-BTY-103 | General Microbiology | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY-104 | General Microbiology-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| GE-1 | IN-ZOO-101 | Cell Biology | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-ZOO-102 | Cell Biology-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| AECC-1 |  | (English/ MIL) communication/Environmental Studies | 2 | 2 | 10 | 40 | 50 | 3 |
| **2** | CC-3 | IN-BTY-201 | Enzymology | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY-202 | Enzymology-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| CC-4 | IN-BTY-203 | Genetics | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY-204 | Genetics-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| GE-2 | IN-ZOO-201 | Mammalian -Physiology | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-ZOO-202 | Mammalian -Physiology-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| AECC-2 |  | (English/ MIL) communication/Environmental Studies | 2 | 2 | 10 | 40 | 50 | 3 |
| **3** | CC- 5 | IN-BTY-301 | Metabolism | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY-302 | Metabolism- Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| CC-6 | IN-BTY-303 | PlantAnatomy and Physiology | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY-304 | Plant Anatomy and Physiology-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| CC-7 | IN-BTY-305 | Inorganic Chemistry-1 | 2 | 2 | 10 | 40 | 50 | 3 |
| IN-BTY-306 | Physical Chemistry-1 | 2 | 2 | 10 | 40 | 50 | 3 |
| IN-BTY-307 | Organic Chemistry-1 | 2 | 2 | 10 | 40 | 50 | 3 |
| IN-BTY-308 | Chemistry-I Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| SEC-1 |  | Computer Science-level-1 | 2 | 2 | 10 | 40 | 50 | 3 |
| GE-3 | IN-ZOO-301 | Developmental Biology | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-ZOO-302 | Developmental Biology-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| AECC-3 |  | Hindi/Sanskrit | 2 | 2 | 10 | 40 | 50 | 3 |
| **4** | CC-8 | IN-BTY-401 | Molecular Biology | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY-402 | Molecular Biology-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| CC-9 | IN-BTY-403 | Animal Biotechnology  | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY-404 | Animal Biotechnology-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| CC-10 | IN-BTY-405 | Inorganic Chemistry-II | 2 | 2 | 10 | 40 | 50 | 3 |
| IN-BTY-406 | Physical Chemistry-II | 2 | 2 | 10 | 40 | 50 | 3 |
| IN-BTY-407 | Organic Chemistry-II | 2 | 2 | 10 | 40 | 50 | 3 |
| IN-BTY-408 | Chemistry-II Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| SEC-2 | IN-BTY-S1 | Bioanalytical Tools  | 2 | 2 | 10 | 40 | 50 | 3 |
|  | OR |
| IN-BTY-S2 | MOOC\* (From Swayam Portal) |  |  |  |  |  |  |
| GE-4 | IN-ZOO-401 | Animal Diversity | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-ZOO-402 | Animal Diversity- Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| **5** | CC-11 | IN-BTY-501 | Recombinant DNA Technology | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY-502 | Recombinant DNA Technology-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| CC-12 | IN-BTY-503 | Plant Biotechnology | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY-504 | Plant Biotechnology- Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| DSE-1 | IN-BTY-505 | Food Technology  | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY-506 | Food Technology-Practicals  | 2 | 4 | 10 | 40 | 50 | 3 |
|  | **OR** |  |
| IN-BTY-507 | Biomathematics | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY-508 | Biomathematics-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
|  | **OR** |  |
| IN-BTY-509 | MOOC\* |  |  |  |  |  |  |
| DSE-2 | IN-BTY-510 | MOOC\* |  |  |  |  |  |  |
|  | OR |  |
| IN-BTY-511 | Medical Biotechnology | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY-512 | Medical Biotechnology-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
|  | **OR** |  |
| IN-BTY-513 | Inorganic Chemistry-III | 2 | 2 | 10 | 40 | 50 | 3 |
| IN-BTY-514 | Physical Chemistry-III | 2 | 2 | 10 | 40 | 50 | 3 |
| IN-BTY-515 | Organic Chemistry-III | 2 | 2 | 10 | 40 | 50 | 3 |
| IN-BTY-516 | Chemistry-III Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| GE-5 | IN-ZOO-501 | Evolutionary Biology | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-ZOO-502 | Evolutionary Biology-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| **6** | CC-13 | IN-BTY-601 | Genomics & Proteomics | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY-602 | Genomics & Proteomics-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| CC-14 | IN-BTY-603 | IPR, Bioethics and Biosafety  | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY-604 | IPR, Bioethics and Biosafety – Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| DSE-3 | IN-BTY-605 | Immunology | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY-606 | Immunology-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
|  | **OR** |  |
| IN-BTY-607 | Bioinformatics | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY -608 | Bioinformatics-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| DSE-4 | IN-BTY-609 | Molecular diagnostics | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY-610 | Molecular diagnostics -Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
|  | **OR** |  |
| IN-BTY-611 | Inorganic Chemistry-IV | 2 | 2 | 10 | 40 | 50 | 3 |
| IN-BTY-612 | Physical Chemistry-IV | 2 | 2 | 10 | 40 | 50 | 3 |
| IN-BTY-613 | Organic Chemistry-IV | 2 | 2 | 10 | 40 | 50 | 3 |
| IN-BTY-614 | Chemistry-IV Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| GE-6 | IN-ZOO-601 | Ecology and Environment management | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-ZOO-602 | Ecology and Environment management-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| **7** | CC-15 | IN-BTY -701 | Advanced Molecular Biology | 4 | 4 | 20 | 80 | 100 | 3 |
|  | IN-BTY -702 | Advanced Molecular Biology-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| CC-16 | IN-BTY -703 | Bioprocess and fermentation Technology | 4 | 4 | 20 | 80 | 100 | 3 |
|  | IN-BTY -704 | Bioprocess and fermentation –Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| CC-17 | IN-BTY -705 | Biostatistics | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY -706 | Biostatistics-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| DSE-5 | IN-BTY -707 | Nanotechnology | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY -708 | Nanotechnology-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
|  | **OR** |  |
| IN-BTY -709 | Medicinal Microbiology | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY -710 | Medicinal Microbiology –Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
|  | **OR** |  |
| IN-BTY -711 |  | MOOC\* |  |
| **8** | CC-18 | IN-BTY -801 | Advanced Recombinant DNA Technology | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY -802 | Advanced Recombinant DNA Technology-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| CC-19 | IN-BTY -803 | Animal Cell Culture | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY -804 | Animal Cell Culture Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| CC-20 | IN-BTY -805 | Bioentrepreneurship Development | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY -806 | Bioentrepreneurship Development -Practicals  | 2 | 4 | 10 | 40 | 50 | 3 |
| Open Elective | IN-BTY -807 | Biotechnology and Human Welfare-I | 2 | 2 | 10 | 40 | 50 | 3 |
|  | OR |
| IN-BTY -808 | One month summer/Industrial Training |  |  |  |  |  |  |
|  |  OR |
| IN-BTY-809 | MOOC from Swayam portal |  |  |  |  |  |  |
| **9** | CC-21 | IN-BTY -901 | Bioinstrumentation | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY -902 | Bioinstrumentation-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| CC-22 | IN-BTY -903 | Research Methodology | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY -904 | Research Methodology-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| CC-23 | IN-BTY -905 | Enviornmental Biotechnology | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY -906 | Enviornmental Biotechnology-Practicals  | 2 | 4 | 10 | 40 | 50 | 3 |
| DSE-6 | IN-BTY -907 | Immunology | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY -908 | Immunology-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
|  | OR |
| IN-BTY -909 | Bioinformatics | 4 | 4 | 20 | 80 | 100 | 3 |
| IN-BTY -910 | Bioinformatics-Practicals | 2 | 4 | 10 | 40 | 50 | 3 |
| Open Elective | IN-BTY-911 | Biotechnology and Human Welfare-II | 2 | 2 | 10 | 40 | 50 | 3 |
|  | OR |
| IN-BTY-912 | One month summer/Industrial Training |  |  |  |  |  |  |
|  | OR |
| IN-BTY-913 | MOOC from Swayam portal |  |  |  |  |  |  |
| **10** | CC-24 | IN-BTY-1000 | Project | 20 |  |  |  |  | 500 |

**Programme Outcomes (POs) for UG courses of Faculty of Life Sciences**

1. To develop skills in graduate students to be able to acquire theoretical and practical knowledge in fundamentals of biology in respective disciplines of plants, animals, microbes and environment.
2. To inculcate ability to critically evaluate problems and apply lateral thinking and analytical skills for professional development.
3. To create awareness on ethical issues, good laboratory practices and biosafety.
4. To develop ability in youth for understanding basic scientific learning and effective communication skills.
5. To prepare youth for career in teaching, industry, government organizations and self reliant entrepreneurship.
6. To make students aware of natural resources and environment and its sustainable utilization.
7. To provide learning experience in students that instills deep interest in biological science for the benefit of society.

**Programme Specific Outcomes (PSOs) for UG courses in Biotechnology**

After the successful completion of the programme the student will be able to

**PSO1 :** demonstrate the knowledge and understanding of biological sciences i.e. structure and function of biological molecules, biological mechanisms, such as the processes and control of bioenergetics and metabolism, as chemical reactions with engineering technologies to manipulate living organisms and biological systems to produce products that advance healthcare, medicine, agriculture, food, pharmaceuticals and environment control

**PSO2 :**critically think and correlate the biological knowledge of distribution, morphology and physiology of organisms (animals, plants and microorganisms) to techniques in aseptic procedures, isolation, identification, characterization and modifications to improve quality of life in person as well as community.

**PSO3 :** demonstrate an understanding of the principles of bio- techniques, and exhibit basic professional skills pertaining to biotechnology, carry out laboratory-orientated numerical calculations and analyse biological data (e.g. in enzyme kinetics, molecular structure analysis, microbiological techniques, immunological inferences)

**PSO4** :scientific writing and authentic reporting, effective presentation skills and ability to work in a group with cooperation

**Semester – I**

**CC-BIOTECHNOLOGY-1**

**Paper: IN-BTY-101**

**BIOMOLECULES-I**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes**: After the successful completion of the course the student will be able to

* 1. Classify, define and explain various properties of carbohydrates and correlate them to their functions.
	2. Classify, define, draw structures and explain functions of various types of lipids: Illustrate various parameters of characterization of lipids.
	3. Classify, draw structures of standard amino acids, explain chemical and physical properties of amino acids; Describe different classes of proteins and explain different levels of structural organization in protein architecture
	4. Explain the characteristics and draw structures of various types of nucleic acids and illustrate the chemical and physical properties of nucleic acids

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**Unit I**

**Biomolecules**: Introduction, important features, covalent and non-covalent interactions.

**Carbohydrates**: Introduction and Biological Significance. Definition and classification: Monosaccharides; families of monosaccharides; simple aldoses and ketoses, Configuration and Conformation, Stereoisomerism/ Asymmetric centres, Fischer and Haworth projection formula, pyranose and furanose ring forms, reducing and non-reducing sugars, sugar derivatives viz. sugar alcohols, amino sugars, deoxy sugars, acidic sugars, Glycosidic bond Disaccharides and Oligosaccharides: Definition, structure and function of important di and oligosaccharides viz. lactose, sucrose, maltose, raffinose, stachyose, verbascose etc. Polysaccharides: Homo and Hetero polysaccharides, storage polysaccharides: Starch and Glycogen. Structural polysaccharides: Cellulose and Chitin. A brief account of structure and function of mucopolysaccharides/Glycosaminoglycans (Hyaluronic acid, Chondroitin sulphate), Glycoproteins and Proteoglycans.

**Lipids:** Introduction and Classification – simple and complex lipids, Fatty acids - structure and nomenclature, soap value, acid value, iodine number, rancidity. Essential fatty acids. A general account of structure and function of triacylglycerols, phospholipids, glycolipids, sphingolipids, steroids, bile acids, bile salts and terpenes

**Unit II**

**Amino acids and Peptides**: Classification and structure of amino acids, essential amino acids, rare and non-protein amino acids, optical and chemical properties of amino acids; acid-base behavior/zwitterions; pKa value and titration curve. Peptide bond – nature and characteristics.Definition; structure and function of some biologically important peptides.

**Proteins:** Classification based on structure and function. Structural organization of proteins: Primary structure; Secondary structure-α-Helix, β- pleats and β - turn Tertiary structure – myoglobin and lysozyme etc. Quaternary structure-hemoglobin.Forces stabilizing different structural levels. Amino acid analysis/N-terminal amino acid analysis- Sanger’s method, Edmann’s degradation, Dansyl chloride and Dabsyl chloride

**Nucleotides and Nucleic acids:** Building blocks: bases, sugars and phosphates. Structure and nomenclature of nucleosides and nucleotides; polynucleotides, DNA (A, B, Z-DNA) and RNA (rRNA, mRNA, tRNA).Properties of DNA - absorption, denaturation, renaturation, hybridization, Tm/Cot values.Biologically important nucleotides and their functions - ATP, GTP, Coenzyme A, NAD+, FAD and cAMP.

**Suggested readings:**

1. Principles of Biochemistry - Albert L. Lehninger, CBS Publishers & Distributors
2. Biochemistry - Methews and Methews
3. Biochemistry - Voet and Voet
4. Biochemistry - KeshavTrehan Wiley Eastern Publications
5. Fundamentals of Biochemistry - J.L. Jain, S. Chand and Company

**Semester – I**

**CC- BIOTECHNOLOGY-1**

**Paper: IN-BTY- 102**

**BIOMOLECULES- PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes**: On successful completion of the course the student will be able to

* 1. Prepare various types of solutions used in qualitative and quantitative biochemical estimations; verify and apply the basic principles of spectroscopy
	2. Analyse the unknown samples qualitatively for the presence of various biomolecules

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practical’s, records and viva voce.

**Practicals:**

1. Preparation of normal, molar, percent solutions, buffer solutions and determination of their pH.
2. Qualitative tests for Carbohydrates
3. Qualitative tests for lipids
4. Qualitative tests for amino acids and Proteins
5. Estimation of acid value and saponification value of fat sample
6. Verification of Beer- Lambert’s Law.

**Suggested reading**

1. Introductory Practical Biochemistry by S.K.Sawhney& R. Singh (2000). Narosa Publishers
2. Practical Biochemistry by David Plummer (1990). Tata Mc-Graw Hill
3. Biochemical Methods by Sadasivam&Manickam (1996) New Age International (P) Ltd.
4. Modern Experimental Biochemistry, 3rd edition, by R. Boyer (2002) Addison-Wesley Longman.
5. A Lab. Manual in Biochemistry by J. Jayaraman (1996) New Age International (P) Ltd.

**Semester – I**

**CC-BIOTECHNOLOGY-2**

**Paper: IN-BTY-103**

**GENERAL MICROBIOLOGY**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes**: On successful completion of the course the student will be able to

* 1. Illustrate the knowledge of history, scope, classification, various approaches of study and microbial diversity
	2. Compare and characterize prokaryotic and eukaryotic cells based on morphology; different groups of microorganisms based on their structures.
	3. Give an account of microbial growth, reproduction and metabolism
	4. Identify the microorganisms in water and food along with methods to control them

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**UNIT I**

**Microbial Taxonomy and classification**: Fundamentals, History and Evolution of Microbiology. Classification of microorganisms: Microbial taxonomy, criteria used including molecular approaches, Microbial phylogeny and current classification of bacteria. Microbial Diversity:

**Distribution and characterization**: Prokaryotic and Eukaryotic cells, Morphology and cell structure of major groups of microorganisms eg. Bacteria, Algae, Fungi, Protozoa and Unique features of viruses.

**Cultivation and Maintenance of microorganisms**: Nutritional categories of micro-organisms, methods of isolation, Purification and preservation.

**UNIT II**

**Microbial growth:** Growth curve, Generation time, synchronous batch and continuous culture, measurement of growth and factors affecting growth of bacteria. Microbial Metabolism: Metabolic pathways, amphi-catabolic and biosynthetic pathways Bacterial Reproduction: Transformation, Transduction and Conjugation. Endospores and sporulation in bacteria.

**Control of Microorganisms:** By physical, chemical and chemotherapeutic Agents

**Food and Water Microbiology:** Bacterial pollutants of water, coliforms and non coliforms.Sewage composition and its disposal. Important microorganism in food Microbiology: Moulds, Yeasts, bacteria. Major food born infections and intoxications, Preservation of various types of foods.Fermented Foods.

**SUGGESTED READING**

1. Alexopoulos CJ, Mims CW, and Blackwell M. (1996).Introductory Mycology. 4 th edition. John and Sons, Inc.
2. Jay JM, Loessner MJ and Golden DA.(2005). Modern Food Microbiology.7thedition, CBS Publishers and Distributors, Delhi, India.
3. Kumar HD. (1990). Introductory Phycology.2nd edition.Affiliated East Western Press.
4. Madigan MT, Martinko JM and Parker J. (2009). Brock Biology of Microorganisms.12th edition.Pearson/Benjamin Cummings.
5. Pelczar MJ, Chan ECS and Krieg NR.(1993). Microbiology.5th edition. McGraw Hill Book Company.
6. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan.
7. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9 th edition. Pearson Education.

**Semester – I**

**CC- BIOTECHNOLOGY-2**

**Paper: IN-BTY- 104**

**GENERAL MICROBIOLOGY- PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes**: On successful completion of the course the student will be able to

* 1. Exhibit skills in preparation of media and staining
	2. Isolate bacteria from different sources and determine their count and cell size

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

 **PRACTICALS**

1. Isolation of bacteria & their biochemical characterization.
2. Staining methods: simple staining, Gram staining, spore staining, negative staining, hanging drop.
3. Preparation of media & sterilization methods
4. Methods of Isolation of bacteria from different sources.
5. Determination of bacterial cell size by micrometry.
6. Enumeration of microorganism - total & viable count.

**SUGGESTED READING**

1. Alexopoulos CJ, Mims CW, and Blackwell M. (1996).Introductory Mycology. 4 th edition. John and Sons, Inc.
2. Jay JM, Loessner MJ and Golden DA.(2005). Modern Food Microbiology.7thedition, CBS Publishers and Distributors, Delhi, India.
3. Kumar HD. (1990). Introductory Phycology.2nd edition.Affiliated East Western Press.
4. Madigan MT, Martinko JM and Parker J. (2009). Brock Biology of Microorganisms.12th edition.Pearson/Benjamin Cummings.
5. Pelczar MJ, Chan ECS and Krieg NR.(1993). Microbiology.5th edition. McGraw Hill Book Company.
6. Stanier RY, Ingraham JL, Wheelis ML, and Painter PR. (2005). General Microbiology. 5th edition. McMillan.
7. Tortora GJ, Funke BR, and Case CL. (2008). Microbiology: An Introduction. 9 th edition. Pearson Education.
8. Willey JM, Sherwood LM, and Woolverton CJ.(2008). Prescott, Harley and Klein’s Microbiology.7th edition.McGraw Hill Higher Education.

AECC-1 -(English/ MIL) communication / Environmental Studies will be same as AECC approved by UGBOS, Department of English/ UGBOS, Department of Environment Sciences, KUK

**Semester – I**

**GE-ZOOLOGY-1**

**Paper: IN-ZOO-101**

**CELL BIOLOGY**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes**: After the successful completion of the course the student will be able to

**101.1**  Understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles

**101.2** Understand how these cellular components are synthesized and degraded in cells

**101.3**  Explain the structure and function of prokaryotic cell & its components

**101.4** Describe the various models and solute transporter systems belonging to cell membrane and will explain cell cycle and apoptosis

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**Unit-I**

**Basics of Cell Biology** – Discovery of cell and Cell Theory; Comparison between plant and animal cells;

**Cell Structure**-Protoplasm ;Cell wall; Plasma membrane; Modification of plasma membrane and intracellular junctions; Cytoskeleton; Mitochondria; Chloroplast; ER; Golgi complex; Lysosome, endosome and microbodies; Ribosome; Centriole; Nucleus;Chromosomes, Chemical components of a cell; Catalysis and use of energy by cells.

**Biogenesis of Cellular organelles** – Biogenesis of mitochondria, chloroplast, ER,

Golgi complex; Biosynthetic process in ER and golgi apparatus; Protein synthesis andfolding in the cytoplasm; Degradation of cellular components.

**Unit-II**

**Structure and function of Prokaryotic cell & its components** - The Slime and the cell wall of bacteria containing peptidoglycan and related molecules; the outer membrane of Gram-negative bacteria, the cytoplasmic membrane. Water and ion transport, mesosomes, flagella, Pilus, fimbriae, ribosomes,carboxysomes, sulfur granules, glycogen, polyphosphate bodies, fat bodies, gas vesicles; endospores,exospores, cysts. Mycelia of fungi and Actinomycetes, Cytoskeleton filament, heterocysts and akinets of Cyanobacteria, Gliding and motility.

**Membrane structure & transport** – Models of membrane structure, Membrane lipids, proteins and carbohydrates; Solute transport by Simple diffusion, Facilitated diffusion and Active transport

**Cell cycle -** An overview of cell cycle; Components of cell cycle control system;

Intracellular and Extra-cellular control of cell division, Programmed cell death (Apoptosis).

**REFERENCES**

1. Molecular Biology of cell – Bruce Alberts et al, Garland publications
2. Animal Cytology & Evolution – MJD, White Cambridge University Publicatins
3. Molecular Cell Biology – Daniel ,Sceintific American Books.
4. Cell Biology – Jack D.Bruke, The William Twilkins Company.
5. Cell Biology – Ambrose &DorouthyMEasty, ELBS Publications.
6. Fundamentals of Cytology – Sharp, Mc Graw Hill Company
7. Cytology – Wilson &Marrision, Reinform Publications
8. Molecular Biology – Smith Faber & Faber Publications
9. Cell Biology & Molecular Biology – EDP Roberties& EMF Roberties, Sauder College.

**Semester – I**

**GE-ZOOLOGY-1**

**Paper: IN-ZOO-102**

**CELL BIOLOGY-PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes**: On successful completion of the course the student will be able to

**102.1**  Prepare slides of animal and plant cells and cell division

**102.2** Conduct the morphomatric analysis of chromosomes

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. Cell division: Permanent slides of animal and plant cells and cell division;
2. Mitotic studies in onion root tip
3. meiotic studies in grasshopper testes/flower buds
4. Chromosomes: Mounting of polytene chromosomes
5. Effect of different osmotic concentration solutions on animal and plant cells
6. Buccal smear – Barr bodies

**Semester – 2**

**CC- BIOTECHNOLOGY-3**

**Paper: IN-BTY- 201**

**ENZYMOLOGY**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes:** After successful completion students will be able to

* 1. Define various characteristics of enzymes, classify them and elaborate the role of cofactors in enzyme catalysis
	2. Correlate the structure of enzymes to their functions, mechanism of enzyme catalysis and describe various approaches for purification of enzymes
	3. Exhibit the knowledge of enzyme kinetics of unisubstrate reactions, various kinetics parameters (Km, Vmax etc.) and describe different types of enzyme inhibitions.
	4. Correlate different ways of enzyme regulation to cellular metabolism: discuss and analysethe industrial importance of enzymes and the techniques to use them.

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**Unit- I**

**Enzymes:** Historical perspectives, general characteristics, nomenclature & classification, significance of numbering system, holoenzyme, apoenzyme, coenzymes, cofactors, activators, inhibitors, active site, metallo-enzymes, isoenzymes, monomeric enzymes, oligomeric enzymes, multifunctional enzyme and multi-enzyme complexes. Enzyme specificity. Measurement and expression of enzyme activity: Enzyme assay, enzyme units, enzyme turn over number and specific activity. Role of cofactors in enzyme catalysis: NAD/NADP, FMN/FAD, coenzyme A, biocytin, Vitamin B12 Coenzyme, lipoamide, TPP, pyridoxal phosphate, tetrahydrofolate and metal ions with special emphasis on coenzyme functions

**Enzyme catalysis:** Reaction co-ordinate diagram, transition state, Acid-base catalysis, covalent catalysis, proximity and orientation effects, strain and distortion theory. Mechanism of action of chymotrypsin, carboxypeptidase, andribonuclease.

**Enzyme Purification:** Methods of isolation of enzymes, purification of enzymes - ammonium sulfate precipitation, molecular-sieving, ion-exchange chromatography, affinity chromatography, criteria of homogeneity and determination of molecular weight of enzyme.

**Unit- II**

**Enzyme Kinetics:** Factors affecting enzyme activity- enzyme concentration, substrate concentration, pH and temperature. Derivation of Michaelis - Menten equation for uni-substrate reactions. Km and its significance.Lineweaver-Burk plot.Importance of Kcat/Km. Bi-substrate reactions- brief introduction of sequential and ping-pong mechanisms with examples.Reversible (competitive, non-competitive and uncompetitive inhibitions) and irreversible inhibition.Determination of Km &Vmax in the presence and absence of inhibitor.

**Enzyme regulation:** Feedback inhibition, Allosteric enzymes. Covalently modulated enzymes.Zymogen activation.

**Immobilized enzymes:** Advantages, methods of immobilization - Adsorption, ionic binding, covalent coupling, cross-linking, entrapment, microencapsulation etc. Applications of immobilized enzymes (A brief account).Industrial applications of enzymes (Production of glucose from starch, cellulose and dextran; use of lactase in dairy industry; production of glucose-fructose syrup from sucrose; use of protease in food, detergent and leather industry).

**Suggested readings:**

1. Enzymes: Biochemistry, Biotechnology and Clinical Chemistry by Trevor Palmer (2001) Horwood Publishing.
2. Fundamentals of Enzymology, 3rd edition, by Nicholas C. Price and Lewis Stevens (1999) Oxford U.
3. The Chemical Kinetics of Enzyme action by K.J. Laidler and P.S. Bunting, Oxford University Press London.
4. Structure and mechanism in Protein Science, 2nd edition, by Alan Fersht (1999). W.H. Freeman and Co., NY

**Semester – 2**

**CC- BIOTECHNOLOGY-3**

**Paper: IN-BTY- 202**

**ENZYMOLOGY-PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes:** After successful completion students will be able to

202.1 Extract and quantitatively estimate the enzyme activity and protein content of the samples

202.2 Exhibit skills in studying various characteristics of enzymes like pH optima, temperature optima, Km, Vmax

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. Estimation of protein by Biuret / Lowry method
2. Assay of acid phosphatase activity from germinating mungbean seeds and calculation of specific activity of acid phosphatase.
3. Effect of enzyme concentration on enzyme activity.
4. Effect of substrate concentration on acid phosphatase activity and determination of its Km value.
5. Effect of pH on enzyme activity and determination of optimum pH.
6. Effect of Temperature on Enzyme activity.

**Suggested reading:**

1. Introductory Practical Biochemistry by S.K.Sawhney& R. Singh (2000). Narosa Publishers
2. Practical Biochemistry by David Plummer (1990). Tata Mc-Graw Hill
3. Biochemical Methods by Sadasivam&Manickam (1996) New Age International (P) Ltd.
4. Modern Experimental Biochemistry, 3rd edition, by R. Boyer (2002) Addison-Wesley Longman.
5. A Lab. Manual in Biochemistry by J. Jayaraman (1996) New Age International (P) Ltd.

**Semester – 2**

**CC- BIOTECHNOLOGY-4**

**Paper: IN-BTY- 203**

**GENETICS**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes:** After successful completion students will be able to

* 1. Exhibit conceptual understanding of laws of inheritance, genetic basis of loci and alleles and their linkage.
	2. Comprehend the effect of chromosomal abnormalities in numerical as well as structural changes leading to genetic disorders.
	3. Develop critical understanding of chemical basis of genes and their interactions at population and evolutionary levels.
	4. Analyze the effect of mutations on gene functions and dosage

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**Unit- I**

**Genetics** - Definition, history and scope

**Mendelism & Chromosome Theory:** Mendel’s principles, applications of Mendel’s principles,Chromosome Theory of Heredity (Sutton-Boveri), Inheritance patterns, phenomenon of Dominance, Inheritance patterns in Human (Sex-linked, Autosomal, Mitochondrial, Unifactorial , Multi-factorial). Deviation from Mendel’s Dihybrid phenotype, Linkage, Sutton’s view on linkage, Morgan’s view on linkage, Bateson & Punnet’s Coupling & Repulsion hypothesis.

**Linkage & Crossing over:** Chromosome theory of Linkage, kinds of linkage, linkage groups, types of Crossing over, mechanism of Meiotic Crossing over, kinds of Crossing over, theories about the mechanism of Crossing over, cytological detection of Crossing over, significance of Crossing over.

**Allelic Variation & Gene function –** Multiple allele, Genetic interaction, Epiststic interactions, Non-Epistatic inter-allelic genetic interactions, Atavism/Reversion, Penetrance (complete & incomplete), Expressivity, Pleiotropism, Modifier/Modifying genes.

**Non-Mendelian inheritance** – Evidences for Cytoplasmic factors, cytoplasmic inheritance, extranuclear inheritance (mitochondrial, chloroplast)

**Unit- II**

**Chromosomal variation in Number & Structure** – Euploidy, Non-disjunction &Aneuploidy,Aneuploid segregation in plants, Polyploidy in Plants & Animals, Induced Polyploidy, applications of Polyploidy, Chromosomal Mosaics, Giant chromosome, Deletion, Duplication, Inversion, Translocation, Position Effect, Centromeric& Non-centromeric breaks in chromosomes, chromosomal rearrangements in Human being, Chromosomal aberrations & evolution. Gene Mutation

**Chromosome Mapping** - Haploid mapping (2 point & 3 point cross), Diploid mapping (Tetrad analysis), determination of linkage groups, determination of map distance, determination of gene order, cytological mapping.

**Human Cyto-Genetics** – Human karyotype, Banding techniques, classification, use of Human Cyto-genetics in Medical science, Chromosomal abnormalities in spontaneous abortions, viable monosomies&trisomies, chromosomal deletions & duplications, genetics of chromosomal inversions & translocations, human traits, Genomic position effects on Gene expression, Inborn diseases

**Pedigree analysis** – Symbols of Pedigree, Pedigrees of Sex-linked & Autosomal (dominant & recessive), Mitochondrial, Incomplete dominance & Penetrance.

**Suggested readings:**

1. Principles of Gene Manipulations – Old & Primrose, Black Well Scientific Publications.
2. Principles of Genetics – E.J.Gardener, M.J.Simmons and D.P.Snustad, John Wiley & Sons Publications
3. Elements of Genetics – PK Gupta, Rastogi Publications
4. Molecular Biology and Genetic Engineering – PK Gupta
5. Cytogentics, Evolution and Plant Breeding – PK Gupta

**Semester – 2**

**CC BIOTECHNOLOGY-4**

**Paper: IN-BTY- 204**

**GENETICS-PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes:** After successful completion students will be able to

204.1 Identify various stages of mitotic and meiotic cell cycles

204.2 Analyze the effect of mutations on gene functions

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals**

1. Cell division: Permanent slides of animal and plant cells and cell division;
2. Mitotic and meiotic studies in grasshopper testes, onion root tips and flower buds
3. Chromosomes: Mounting of polytene chromosomes
4. Buccal smear – Barr bodies
5. Karyotype analysis – Man and Onion
6. Man – Normal and Abnormal – Down and Turner’s syndromes (with the help of slides)
7. Simple genetic problems (Problems and Interaction of genes)
8. Chromosome mapping using three point test cross; tetrad analysis,
9. Induction and detection of mutations through genetic tests
10. Pedigree analysis in humans,

 **SUGGESTED READING**

1. Gardner, E.J., Simmons, M.J., Snustad, D.P. (2006).
2. Principles of Genetics. VIII Edition John Wiley & Sons. 2. Snustad, D.P., Simmons, M.J. (2009). Principles of Genetics. V Edition. John Wiley and Sons Inc.
3. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics. IX Edition. Benjamin Cummings.
4. Russell, P. J. (2009). Genetics- A Molecular Approach. III Edition. Benjamin Cummings.
5. Griffiths, A.J.F., Wessler, S.R., Lewontin, R.C. and Carroll, S.B. IX Edition. Introduction to Genetic Analysis, W. H. Freeman & Co.

AECC-2 -(English/ MIL) communication / Environmental Studies will be same as AECC approved by UGBOS, Department of English/ UGBOS, Department of Environment Sciences, KUK

**Semester – II**

**GE-ZOOLOGY-2**

**Paper: IN-ZOO-201**

**MAMMALIAN PHYSIOLOGY**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes**: After the successful completion of the course the student will be able to

**201.1** Gain in-depth understanding and appropriate functioning of digestive and cardiovascular system in animals

**201.2** Describe the Physiology of humanrespiration&excretion

**201.3** Understand the functioning of nerve impulse&reflex action and will explain about different types ofmuscles and their physiology in human

**201.4** Explain the mechanism of action of hormones and related molecules involved in various physiological processes and will describe about human reproductive system

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**Unit-1**

**Digestive system:** Types of nutrition, ingestion, digestion, absorption, and assimilation, BMR.

**Cardiovascular System:** Types of circulatory systems, Composition of Blood, blood coagulation, Haemopoiesis, blood volume, blood pressure, control of blood pressure, cardiac cycle, origin and conduction of heart beat, control of heart beat, ECG – its principle and significance

**Respiratory system:** transport of gases, exchange of gases, neural and chemical regulation of respiration.

**Excretory system:** excretory products, kidney, structure of nephron, urine formation, urine concentration, micturition, osmoregulation

 **Unit-II**

**Nervous system:** Neurons, generation and transmission of nerve impulse neurotransmitors

**Muscle physiology:** Types of muscular tissue, ultrastructure of myofibrillar filaments, neuro muscular junctions, physical and chemical changes in muscle contraction, energy for muscle contraction, Cori’s cycle

**Endocrinology:** Endocrine glands and their functions, basic mechanism of Peptide and steroid hormones,

**Reproduction:** Menstrual and oestrual cycle, implantation, gestation, parturition

**Suggested reading:**

1. Guyton Medical Physiology Textbook By Guyton and Hall
2. C. C.Chatterji**,** Human Physiology
3. Human physiology: the basis of medicine [V Higgins](http://bjsm.bmj.com/search?author1=V+Higgins&sortspec=date&submit=Submit)Edited by Gillian Pocock, Christopher D Richards. Published by Oxford University Press, 2004, ISBN 0198585276
4. Ross & Wilson, Anatomy & Physiology in Health & Illness, Churchill Livingstone.Tortora GJ, &Anagnodokos NP, Principles of Anatomy & Physiology, Harper & Rave Publishers, New Delhi.
5. Keele, C.A., Niel, E and Joels N, Samson Wright’s Applied Physiology, Oxford University Press

**Semester – II**

**GE-ZOOLOGY-2**

**Paper: IN-ZOO-202**

**MAMMALIAN PHYSIOLOGY- PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes**: On successful completion of the course the student will be able to

**202.1** analyse blood sample for total blood cell count, TLC, DLC

**202.2** analyze urine sample and identify various tissues

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. Use of Kymograph unit
2. Urine analysis
3. Total RBC count
4. Enumeration of white blood cells using haemocytometer
5. Erythrocyte sedimentation rate
6. Study of permanent slides of mammalian organs such as oesophagus, stomach, ileum, rectum, liver, trachea, lung, kidney etc

**Semester – 3**

**CC-BIOTECHNOLOGY -5**

**Paper: IN-BTY- 301**

**METABOLISM**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes:** After successful completion students will be able to

* 1. Apply the knowledge of biological redox reactions, coupled reactions, energy rich compounds and the energy transactions in studying metabolism; describe the metabolic pathways *i.e.* glycolysis (catabolism), gluconeogensis (anabolism), and TCA cycle and their regulations
	2. Discuss the reactions, regulation and importance of pentose phosphate pathway, glycogen metabolism, glyoxylate, ETC and apply the concept of oxidative phosphorylation to calculate energy production by oxidation of carbohydrates
	3. Describe the reactions and regulation of lipid biosynthesis and catabolism by beta, alpha and omega oxidative pathways: ketone bodies metabolism and integration to the metabolism of other biomolecules
	4. Analyse how amino acid catabolism leads to formation of diverse type molecules including ketone bodies, glucose, urea: discuss the catabolism and anabolismof nucleic acids and porphyrins

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**UNIT-I**

**Bioenergetics:** Concept of free energy, standard free energy, relation between equilibrium constant and standard free energy change and coupled reactions. Biological oxidation-reduction: redox potentials, relation between standard reduction potentials and free energy change (numericals included). High-energy compounds: phosphate group transfer potential, free energy of hydrolysis of ATP, PEP and glucose-6 phosphate along with reasons for high ∆G.

**Carbohydrate Metabolism:** Reactions and energetics of glycolysis. Alcoholic and lactic acid fermentations.Feeder pathways, Entry of fructose into glycolysis.Reactions and energetics of TCA cycle.Regulation of glycolysis and TCA cycle.Gluconeogenesis.Glycogenesis and glycogenolysis.Reactions and physiological significance of pentose phosphate pathway.

**Electron Transport Chain and Oxidative Phosphorylation**: Structure of mitochondria, organization and sequence of electron carriers, sites of ATP production, inhibitors of electron transport chain. Oxidative phosphorylation: chemiosmotic theory, structure of ATP synthase, Inhibitors and uncouplers of oxidative phosphorylation. Transport of reducing equivalents from cytosol into mitochondria.

**UNIT-II**

**Lipid Metabolism:** Introduction, hydrolysis of triacylglycerols, activation of fatty acids, transport of fatty acyl CoA into mitochondria, beta-oxidation of saturated, and odd chain fatty acidss. ATP yield from fatty acid oxidation. Biosynthesis of saturated fatty acids.triglycerides.Metabolism of ketone bodies.

**Amino acid Metabolism:** General reactions of amino acid metabolism: transamination, oxidative and non-oxidative deamination and decarboxylation. Urea cycle.Glycogenic and ketogenic amino acids.Biosynthesis of aromatic amino acids.Glucose-Alanine cycle.

**Nucleotide Metabolism:** Sources of the atoms in the purine and pyrimidine molecules, denovo biosynthesis and degradation of purine and pyrimidine nucleotides, Regulation of purine and pyrimidine biosynthesis. Salvage pathways of purines and pyrimidines.

**Suggested readings:**

1. Lehninger: Principles of Biochemistry, 3rd edition, by David L. Nelson and M.M. Cox (2000) Maxmillan/ Worth publishers.
2. Fundamentals of Biochemistry by Donald Voet and Judith G Voet (1999). John Wiley & Sons, NY
3. Biochemistry, 2nd edition, by R.H. Garrett and C.M. Grisham (1999). Saunders College Publishing, NY.
4. Outlines of Biochemistry by E.E.Conn, P.K.Stumpf, G. Bruenimg and Ray H.Doi (1987). John Wiley & Sons, NY
5. Biochemistry, 2nd edition, by Laurence A. Moran, K.G. Scrimgeour, H. R. Horton, R.S. Ochs and J. David Rawn (1994), Neil Patterson Publishers Prentice Hall.

**Semester – 3**

**CC- BIOTECHNOLOGY-5**

**Paper: IN-BTY- 302**

**METABOLISM-PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes:** After successful completion students will be able to-

302.1 Determine biomolecules in the samples quantitatively.

* 1. Isolate and characterize carbohydrates, lipids and proteins from the natural sources

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals**

1. Estimation of nitrogen by micro-Kjeldahl method.
2. Estimation of blood glucose by colorimetrically.
3. Estimation of ascorbic acid by titrimetric method.
4. Preparation of starch from potato and determination of achromatic point by salivary amylase
5. Isolation of total lipids by Folch method and determine acid value.
6. Isolation of casein from milk and determination of isoelectric pH.

**Suggested reading:**

1. Introductory Practical Biochemistry by S.K.Sawhney& R. Singh (2000). Narosa Publishers
2. Practical Biochemistry by David Plummer (1990). Tata Mc-Graw Hill
3. Biochemical Methods by Sadasivam&Manickam (1996) New Age International (P) Ltd.
4. Modern Experimental Biochemistry, 3rd edition, by R. Boyer (2002) Addison-Wesley Longman.

**Semester – 3**

**CC- BIOTECHNOLOGY-6**

**Paper: IN-BTY- 303**

**PLANT ANATOMY AND PHYSIOLOGY**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning outcomes: :**After successful completion students will be able to-

* 1. Exhibit the knowledge of fundamentals of plant anatomy and examine the internal anatomy of plant organs
	2. Correlate the concept of water relation of plants to various physiological processes and nutrition of plants
	3. Explain the process and significance of Photosynthesis and nitrogen metabolism
	4. Illustrate various phases of plant growth and factors affecting them

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**UNIT I**

**Anatomy**: The shoot and root apical meristem and its histological organization, simple & complex permanent tissues, primary structure of shoot & root, secondary growth, growth rings, leaf anatomy (dorsi-ventral and isobilateral leaf)

**Plant water relations and micro & macro nutrients**: Plant water relations: Importance of water to plant life, diffusion, osmosis, plasmolysis, imbibition, guttation, transpiration, stomata & their mechanism of opening & closing. Micro & macro nutrients: criteria for identification of essentiality of nutrients, roles and deficiency systems of nutrients, mechanism of uptake of nutrients, mechanism of food transport

**UNIT II**

**Carbon and nitrogen metabolism** : Photosynthesis- Photosynthesis pigments, concept of two photo systems, photphosphorylation, calvin cycle, CAM plants, photorespiration, compensation point Nitrogen metabolism- inorganic & molecular nitrogen fixation, nitrate reduction and ammonium assimilation in plants.

**Growth and development** ; Growth and development: Definitions, phases of growth, growth curve, growth hormones (auxins, gibberlins, cytokinins, abscisic acid, ethylene) Physiological role and mode of action, seed dormancy and seed germination, concept of photoperiodism and vernalization

**SUGGESTED READING**

1. Dickinson, W.C. 2000 Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Esau, K. 1977 Anatomy of Seed Plants. Wiley Publishers.
3. Fahn, A. 1974 Plant Anatomy. Pergmon Press, USA and UK.
4. Hopkins, W.G. and Huner, P.A. 2008 Introduction to Plant Physiology. John Wiley and Sons.
5. Mauseth, J.D. 1988 Plant Anatomy. The Benjammin/Cummings Publisher, USA.
6. Nelson, D.L., Cox, M.M. 2004 Lehninger Principles of Biochemistry, 4 th edition, W.H. Freeman and Company, New York, USA.
7. Salisbury, F.B. and Ross, C.W. 1991 Plant Physiology, Wadsworth Publishing Co. Ltd.
8. Taiz, L. and Zeiger, E. 2006 Plant Physiology, 4 th edition, Sinauer Associates Inc .MA, USA

**Semester – 3**

**CC-BIOTECHNOLOGY -6**

**Paper: IN-BTY- 304**

**PLANT ANATOMY AND PHYSIOLOGY-PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes:** After successful completion students will be able to-

* 1. Prepare stained mounts of anatomy and demonstrate physiological processes: plasmolysis, stomata opening, guttation of leaf tips,aerobic respiration
	2. Separate photosynthetic pigments and prepare mounts of root nodules

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**PRACTICALS**

1. Preparation of stained mounts of anatomy of monocot and dicot’s root, stem & leaf.
2. Demonstration of plasmolysis by Tradescantia leaf peel.
3. Demonstration of opening & closing of stomata
4. Demonstration of guttation on leaf tips of grass and garden nasturtium.
5. Separation of photosynthetic pigments by paper chromatography.
6. Demonstration of aerobic respiration.
7. Preparation of root nodules from a leguminous plant.

**SUGGESTED READING**

1. Dickinson, W.C. 2000 Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Esau, K. 1977 Anatomy of Seed Plants. Wiley Publishers.
3. Fahn, A. 1974 Plant Anatomy. Pergmon Press, USA and UK.
4. Hopkins, W.G. and Huner, P.A. 2008 Introduction to Plant Physiology. John Wiley and Sons.
5. Mauseth, J.D. 1988 Plant Anatomy. The Benjammin/Cummings Publisher, USA.
6. Nelson, D.L., Cox, M.M. 2004 Lehninger Principles of Biochemistry, 4 th edition, W.H. Freeman and Company, New York, USA.
7. Salisbury, F.B. and Ross, C.W. 1991 Plant Physiology, Wadsworth Publishing Co. Ltd.
8. Taiz, L. and Zeiger, E. 2006 Plant Physiology, 4 th edition, Sinauer Associates Inc .MA, USA

**CC- BIOTECHNOLOGY-7 Paper IN-BTY-305, IN-BTY-306, IN-BTY-307 and IN-BTY-308 will be same as Core Course CC-1 Chemistry Paper B-CHEM-101,B-CHEM-102, B-CHEM-103 and B-CHEM-104 approved by UG- BOS-Chemistry, Department of Chemistry, Kurukshetra University, Kurukshetra**

**SEC-1 Computer Science-level-1will be same as approved by UGBOS , Department of Computer Science, Kurukshetra University, Kurukshetra**

**Semester – III**

**GE-ZOOLOGY-3**

**Paper: IN-ZOO-301**

**DEVELOPMENTAL BIOLOGY**

 **Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes**: After the successful completion of the course the student will be able to

**301.1** Gain detail understanding ofvarious developmental processes includinggametogenesis, fertilization and different pattern and mechanism of fertilized cell cleavage,

**301.2** Understand the concept of germ layers, their formation and differentiation and will describe about early phase of embryonic development

**301.3** Explain about the concept of differentiation and embryonic induction

**301.4** Describe the development of organ including eye and fate of primary germ layers and will explain the process of aging & senescence in vertebrates

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**Unit I**

Development Biology: Scope & historical perspective

Gametogenesis-Spermatogenesis, Metamorphosis of spermatid, Oogenesis

Fertilization-Definition, mechanism, types of fertilization

Cleavage-definition, types, patterns, Mechanism

Gastrulation- Morphogenetic movements-epiboly, emboly, extension, invagination,

Convergence, de-lamination.

Formation and differentiation of primary germ layers

Fate maps in early embryos

**Unit II**

Differentiation: Cell commitment and determination-epigenetic landscape: a model of determination and differentiation at the level of genome, transcription and post transcriptional

Concept of embryonic induction: Primary, secondary and tertiary embryonic induction. Neuronal induction and induction of vertebrate lens

Pathway selection, target and address selection

Extra embryonic membranes, placenta in mammals

Neurulation, notogenersis, Development of vertebrate eye

Fate of primary germ layers

Development of behaviour: constancy and plasticity

Aging & Senescence

**Suggested Reading:**

**Developmental Biology** by Scott Gilbert

**Semester – II**

**GE-ZOOLOGY-3**

**Paper: IN-ZOO-302**

**DEVELOPMENTAL BIOLOGY-PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes**: On successful completion of the course the student will be able to

**302.1**  Differentiate various life stages of mosquito/frog and will identify chick embryo stages

**302.2**  Able to prepare permanent histological slides

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. Preparation of permanent/temporary slides of developmental stages of frog/mosquito.
2. Study of permanent slides of WM of chick embryo (13-18h, 24-36h, 36-48h, 48-72h).
3. Window preparation and identification of stages of development in chick egg.
4. Histology: Preparation of permanent histological slides of mammalian testes, ovary, kidney, intestine, liver of rat (H & E staining).

 AECC-3 Hindi/Sanskrit will be same as AECC approved by UGBOS, Department of Hindi/ UGBOS, Department of Sanskrit, Kurukshetra University, Kurukshetra.

**Semester – 4**

**CC-BIOTECHNOLOGY-8**

**Paper: IN-BTY- 401**

**MOLECULAR BIOLOGY**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes:** After successful completion students will be able to

401.1 Elaborate the central dogma of life at molecular level and the general principles of gene organization, DNA supercoiling; nucleases and various approaches of sequencing of DNA

401.2 Describe the structure and functions of proteins involved in replication and mechanism of DNA replication and correlate molecular basis of different types of DNA mutations with the repair systems of the mutations

401.3 Give an insight of the process of gene expression, mechanism of transcription, post-transcriptional processing of RNA in prokaryotes; Describe and correlate the concept of genetic code and mechanism of translation in prokaryotes

* 1. Describe the process of regulation of gene expression in prokaryotes and exhibit the knowledge of basics of recombinant technology for the manipulation of genetic information stored in the cells with the help of diverse cloning vectors

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**Unit I**

**Basic Concepts of Genetic Information:** Structure of DNA, various forces responsible for stability of DNA, various forms of DNA, DNA topology, topological and geometric properties, DNA supercoiling, Topoisomerases in prokaryotes and eukaryotes, DNA organization in prokaryotes and eukaryotes, C-value paradox, denaturation: different ways for carrying out denaturation, renaturation: requirements, kinetics, significance, various classes of DNA: highly repetitive, moderately repetitive and unique sequence, RNA: structure and types.

**DNA replication, mutations and DNA repair:** Possible modes of DNA replication, Meselson-Stahl experiment, DNA polymerases and other enzymes involved in DNA replication, Okazaki fragments, Mechanism of replication in prokaryotes and eukaryotes, inhibitors of DNA replication, molecular basis of mutations, DNA repair mechanisms like direct, base-excision, nucleotide-excision, mismatch, SOS and recombinational repair.

**Unit II**

**Transcription and post-transcriptional modifications:** RNA polymerase/s in prokaryotes and eukaryotes, DNA footprinting technique, initiation, elongation and termination of transcription in prokaryotes and eukaryotes, inhibitors of transcription, RNA replicase, reverse transcriptase, post-transcriptional modifications: different types of introns and their splicing mechanisms, processing of mRNA, rRNA and tRNA precursors, overlapping genes and split genes.

**Protein synthesis, targeting and degradation:** Characteristics of the genetic code, biological significance of degeneracy, decoding the code, Wobble hypothesis, ribosomes structure and function in prokaryotes and eukaryotes, Aminoacyl-tRNA-synthetases various factors and steps involved in protein synthesis in prokaryotes and eukaryotes, polyribosomes, post-translational processing, signal hypothesis and protein targeting to lysosomes, Plasma membrane, extracellular matrix and different compartment of mitochondria and chloroplast, protein degradation.

**Suggested readings:**

1. Molecular Cell Biology, 5th edition H Lodish et al. (2004) W H Freeman and Company.
2. Genes VIII, B Lewin (2004) Pearson Education International.
3. Freifelder’s Essentials of Molecular Biology, 4rd edition, D Freifelder. (2005) Narosa publishing house
4. Biochemistry, 2nd edition, Moran. Neil Patterson Publishing.
5. Fundamentals of Biochemistry, 2nd edition, D Voet& G J Voet. John-Wiley & sons.
6. Biochemistry, 5th edition, JM Berg et al. W H Freeman & Co. N York.
7. Lehninger’s Principles of Biochemistry, 4nd edition, D L Nelson and M M Cox. (2005) W H Freeman & Co. N York.
8. The Biochemistry of Nucleic acid, 11th edition, R L Adams et al, Chapman and Hall.
9. Molecular Biology of the Gene, 5th Edition, Watson et al (2004) Pearson Education International.

**Semester –4**

**CC-BIOTECHNOLOGY-8**

**Paper: IN-BTY- 402**

**MOLECULAR BIOLOGY–PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes:** After successful completion students will be able to

* 1. Isolate and quantify genetic material from plant/animal sources by colorimetric methods
	2. Exhibit the skill in separating the fragments of DNA by electrophoresis and characterizing by absorption spectrum.

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. Isolation of DNA from plant/Animal source
2. Estimation of DNA by diphenylamine method.
3. Separation of DNA fragments by Agarose gel electrophoresis
4. Isolation of RNA from spinach leaves/bacteria/yeast
5. Estimation of RNA by orcinol method.
6. Determination of absorption maxima of nucleic acids

**Suggested readings:**

1. Molecular Cell Biology, 5th edition H Lodish et al. (2004) W H Freeman and Company.
2. Genes VIII, B Lewin (2004) Pearson Education International.
3. Freifelder’s Essentials of Molecular Biology, 4rd edition, D Freifelder. (2005) Narosa publishing house
4. Biochemistry, 2nd edition, Moran. Neil Patterson Publishing.
5. Fundamentals of Biochemistry, 2nd edition, D Voet& G J Voet. John-Wiley & sons.
6. Biochemistry, 5th edition, JM Berg et al. W H Freeman & Co. N York.
7. Lehninger’s Principles of Biochemistry, 4nd edition, D L Nelson and M M Cox. (2005) W H Freeman & Co. N York.
8. The Biochemistry of Nucleic acid, 11th edition, R L Adams et al, Chapman and Hall.
9. Molecular Biology of the Gene, 5th Edition, Watson et al (2004) Pearson Education International.

**Semester-4**

**CC-BIOTECHNOLOGY-9**

**Paper: IN-BTY- 403**

**ANIMAL BIOTECHNOLOGY**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes: On successful completion of the course the student will be able to**

* 1. Describe the scope, application of animal biotechnology and elaborate the techniques of gene transfer in mammalian cells
	2. Explain the concept of animal transgenesis and their applications in pathogenesis
	3. Describe about cloning, artificial insemination, their role in animal propagation and will understand the role of biotechnology including IVF and stem cells in conservations of livestock diversity
	4. Elaborate the gene therapy, its type and their role in bioengineering

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**Unit I**

**Animal Biotechnology:**Scope, global perspective and new horizons, Historical perspective, and economically important livestock breeds, Model animals in animal biotechnology and genetic engineering.

**Gene transfer methods in Animals**: DNA transfer techniques into mammalian cells: calcium phosphate precipitation, DEAE-dextran procedure, Microinjection, Electroporation, Selectable markers, Embryonic Stem cell, gene transfer, Retrovirus & Gene transfer.

**Introduction to transgenesis:** Transgenic Animals – Mice, Sheep, Cow, Pig, Goat, Bird, Insect. Animal diseases need help of Biotechnology–Foot-and mouth disease, Coccidiosis, Trypanosomiasis, Theileriosis

**Unit II**

**Animal propagation:** Artificial insemination, Animal Clones (Concepts of animal cloning, Principles and techniques of cloning).

**Conservation Biology**: Biotechnology in conservation of livestock diversity, Superovulation, Embryo biotechnology- Embryo collection, evaluation, and transfer, *In vitro* fertilization (IVF) and *In vitro* embryo production, Cryobanking of germplasm, oocytes and sperm, Somatic and Stem cells; Somatic nuclear transfer (SCNT), Stem technology in livestock

**Genetic modification in Medicin**e - Gene therapy, types of gene therapy, vectors in gene therapy, molecular engineering, human genetic engineering, problems & ethics.

**Suggested Readings:**

1. Animal Cell Culture Methods In: Methods in Cell Biology, Vol. 57, Ed. Jenni P Mather and David Barnes, Academic Press.
2. Animal Cell Culture Techniques. Ed. Martin Clynes, springer.
3. Text Book of Animal Biotechnology- (2020) published by The Energy and Resources Institute Press, New Delhi.
4. Advances in Animal Biotechnology (2020) published by Springer Nature Switzerland AG.
5. Animal Cell Culture - Practical Approach, Ed. John R.W. Masters, OXFORD.
6. Culturing of animal cells by Ian Freshney, 6th edition

**Semester – 4**

**CC-BIOTECHNOLOGY-9**

**Paper: IN-BTY - 404**

**ANIMAL BIOTECHNOLOGY -PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes**: On successful completion of the course the student will be able to

* 1. Prepare different media, culture and cryopreserve the animal cells.
	2. Perform gene transfer technique and demonstrate about animal cloning and IVF

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. Preparation of media for animal cells
2. Preparation of cryopreservation media
3. Isolation and cryopreservation of lymphocytes
4. Freezing/cryopreservation of animal cells and post thaw damages in animal cells after cryopreservation
5. Perform one gene transfer method
6. Demonstrate about animal cloning
7. Demonstrate about *In vitro* fertilization (IVF) including collection of ovaries, maturation of oocytes, recovery of oocytes etc

**Suggested Readings:**

1. Animal Cell Culture - Practical Approach, Ed. John R.W. Masters, OXFORD.
2. Animal Cell Culture Methods In: Methods in Cell Biology, Vol. 57, Ed. Jenni P

Mather and David Barnes, Academic Press.

1. Animal Cell Culture Techniques. Ed. Martin Clynes, springer.
2. Biotechnology, Vol. 7b 1993 Rehm. H.J. and Reed, G.(eds) VCH Publications.
3. Cell Culture Lab Fax. Eds. M Butler & M. Dawson, Bios Scientific Publications Ltd.

Oxford.

1. Cell Growth and Division: a Practical Approach. Ed. R. Basega, IRL Press.
2. Culture of Animal Cells, (3rdedition), R. Ian Freshney. Wiley-Liss.

CC- BIOTECHNOLOGY-10 Paper IN-BTY-405, IN-BTY-406, IN-BTY-407 and IN-BTY-408 will be same as Core Course CC-2 Chemistry Paper B-CHEM-201,B-CHEM-202, B-CHEM-203 and B-CHEM-204 approved by UG- BOS-Chemistry, Department of Chemistry, Kurukshetra University, Kurukshetra

**SEC-BIOTECHNOLOGY**

**Paper: IN-BTY- S1**

**BIOANALYTICAL TOOLS**

**Credits: 2**

**Max. Marks: 50**

**Internal assessment: 10**

**Time: 3 hrs**

**Learning Outcomes:** Students who successfully complete this course will be able to

S1.1 Demonstrate the knowledge of the general principles, components and applications of pH meter and centrifuges;

S1.2 Exhibit the insights of principles and applications of chromatographic techniques in isolation, quantification and characterization of biomolecules

S1.3 Demonstrate the knowledge of the general principles, components and applications of spectrophotometer;

S1.4 Describe the principles and applications of electrophoresis and radioisotopes in biochemical studies.

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**Unit- I**

**Measurement of pH:** Principles of glass and reference electrodes.

**Hydrodynamic Methods:** Sedimentation: sedimentation velocity including factors affecting it, preparative and analytical centrifugation techniques, ultracentrifugation, determination of molecular weight by hydrodynamic methods (derivations excluded and numericals included).

**Chromatographic techniques**- General principles and applications of adsorption, ion-exchange, molecular-sieve, thin layer, hydrophobic, affinity & paper chromatography.

**Unit- II**

**Electrophoresis**- Basic principles of electrophoresis; Native & SDS-PAGE; Agarose gel electrophoresis and Isoelectricfocussing.

**Radioisotopic Techniques:** Types of radiations, radioactive decay, units of radioactivity, detection and measurement of radioactivity (methods based on gas ionization and liquid scintillation counting) and Quenching. Autoradiography: overview, nuclear emulsions used in biological studies, isotopes commonly used in biochemical studies (32P, 35S, 14C and 3H), track length of emitted particles and physical arrangements between emitting source and emulsion. Biological hazards of radiations and safety measures in handling radioisotopes.Biological applications of radioisotopes.

**Spectroscopic Techniques:** Beer-Lambert law, light absorption and its transmittance, extinction coefficient, a brief account of instrumentation and applications of visible and UV spectroscopic techniques (structure elucidation excluded).

**Suggested readings:**

1. Physical Biochemistry, 2nd edition, by D Friefelder (1983). W.H. Freeman & Co., U.S.A.
2. Biophysical Chemistry: Principles and Techniques, 2nd edition, by A. Upadhyay, K. Upadhyay and N.Nath. (1998). Himalaya Publishing House, Delhi.
3. Principles & Techniques of Practical Biochemistry, 5th edition, by Keith Wilson and John Walker (2000). Cambridge University Press.
4. Introductory Practical Biochemistry by S.K. Sawhney and Randhir Singh (2000). Narosa Publishing House, New Delhi.

**Semester – IV**

**GE-ZOOLOGY-4**

**Paper: IN-ZOO-401**

**ANIMAL DIVERSITY**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes**: After the successful completion of the course the student will be able to

**401.1** Describe unique characters, diversity and ecological role of phylum Protozoa, Porifera, Coelenterate & Helminthes

**401.2** Explain in detail about the characters, diversity and ecological role of phylum Arthropoda, Mollusca&Echinodermata

**401.3** Identify different Urochordates, Cephalochordates, about their adaptations and associations in relation to their environment.

**401.4** Identify (based on morphological characters) and understand adaptations in vertebrate class including amphibians, reptiles, birds, and mammals.

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**Unit-1**

General classification of animal kingdom

**Non-chordates** –Study of phylum Protozoa, Porifera, Ceolenterata,Platyhelmenthes, Nemathelmenthes, Arthropoda, Mollusca&

Echinodermata – General characters, biodiversity with economic importance

**Unit-2**

**Chordates:-**

Study of Urochordates ,Cephalochordates and Vertebrates-Generalcharacters ,biodiversity with economic importance

REFERENCES

|  |
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|  |

* Invertebrate by Jordan and Verma
* Invertebrate by Kotpal
* Non Chordate by Dhami and Dhami
* Chordate Zoology by Verma
* Chordate Zoology by Kotpal
* Chordate Zoology by Jordan
* Chordate Zoology by Dhami and Dhami

**Semester – IV**

**GE-ZOOLOGY-4**

**Paper: IN-ZOO-402**

**ANIMAL DIVERSITY-PRACTICALS**

 **Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes:** After successful completion of this course students will be able to

**402.1** Identify invertebrates and vertebrate specimeas well as classify them

**402.2** Prepare slides of different parts as was whole mounts of vertebrate and Invertebrate

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. To study permanent slides of protozoans available
2. To study specimens from various Invertebrate groups
3. Preparation of temporary whole mounts of insect mouthparts
4. Prepare slides of piscean scales,feathers,amphioxus,herdmania spicules
5. To study specimens of vertebrate groups

**Semester – V**

**CC-BIOTECHNOLOGY-11**

**Paper: IN-BTY - 501**

**RECOMBINANT DNA TECHNOLOGY**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes**: On successful completion of the course the student will be able to

* 1. Understand the concept and scopes of Genetic Engineering and central role of recombinant DNA technology in all fields of Biotechnology
	2. Learn about enzymes, vectors, and their types to be used in the recombinant DNA technology
	3. Describe about different methodologies to be used for the isolation and analysis of genomic and nuclear DNA
	4. Illustrate about the PCR, their types along with strategies required for gene cloning purpose including preparation of competent cell, introduction of foreign DNAs into competent cells and selection of recombinants.

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**Unit I**

**Genetic Engineering**: Introduction, scope and applications of Genetic Engineering, Miles stones in Genetic engineering, Central role of E.coli.

**Gene Modifying Enzymes**: DNA polymerase, Polynucleotide kinase, Terminal deoxynucleotidy1 transferase, Reverse transcriptase, Restriction endonucleases (R.E.) - Host controlled restriction and modification, Nomenclature, types, Recognition sequence, blunt and sticky ends, applications, online tools & Database (like REBASE) for studyingrecognition site and about R.E. enzymes, Nucleases, Methylases, Alkaline phosphatase, Ligases- E. coli and T4 DNA ligases, Linker, Adaptor, Homopolymer tailing, Nick translation system

**Gene Cloning Vectors**: Types, classes and uses of cloning vectors *viz.* Plasmids, Cosmids, Phagemid

Plasmid Biology: Structural and Functional Organization of Plasmids, Plasmid Replication, Stringent and Relaxed Plasmids, Incompatibility of Plasmid Maintenance, Ti plasmids,

Biology of Bacteriophage Lambda: Lambda Phage as a natural *in vivo* vector, *in vitro* construction of lambda vector, Bacteriophage (ssDNA Phages), Cauliflower Mosaic Virus, Artificial chromosomes (YAC, BAC, PAC).

**Unit II**

**Isolation & Analysis of Genomic and Nuclear DNA**: Purification of total cell DNA, plasmid DNA, phage DNA, DNA digestion and restriction fragment analysis and sequencing by chemical, enzymatic and BigDye terminator methods.

**Polymerase Chain Reaction:** Concept, Basic PCR reaction, Factors affecting the PCR, Types of PCR (RT- PCR, Real time PCR, Allele specific PCR, Multiplex PCR), Applications of PCR, Preparation of Primers by using online tools

**Cloning and Subcloning Strategy**: Construction of recombinant DNA: Preparation of competent cell - Transformation, Transfection – Selection and Screening of Recombinants (bacteria and phages); Cloning strategies in yeast, *E. coli* and *B. subtilis*

**Suggested Readings:**

1. “Principles of Gene Manipulation” by R.W.Old and S.B.Primrose Third Edition Blackwell Scientific Publication
2. “Genes VI” by B. Lewin
3. “From Genes to Clones” by E. L. Winnecker.
4. “Gene Cloning “ by T. A. Brown

**Semester – 5**

**CC-BIOTECHNOLOGY-11**

**Paper: IN-BTY - 502**

 **RECOMBINANT DNA TECHNOLOGY-PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes**: On successful completion of the course the student will be able to

* 1. Isolate nucleic acids, quantify and analyze by gel electrophoresis
	2. Exhibit the skill in designing primers and exploring restriction enzymes by using online database and will also carry out restriction digestion and perform PCR based analysis to study recombinant genes

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. To perform plasmid isolation from *E.Coli* and its quality determination by agarose gel electrophoresis.
2. Designing primers in Gene Runner for PCR.
3. To perform PCR with given template and primers.
4. Demonstrate about RT-PCR
5. To perform Restriction digestion of given DNA sample.
6. Exploration of Restriction Enzyme Database REBASE
7. Drawing vector DNA map with specified features.

**Suggested readings:**

1. “Principles of Gene Manipulation” by R.W.Old and S.B.Primrose Third Edition Blackwell Scientific Publication
2. “Genes VI” by B. Lewin
3. “From Genes to Clones” by E. L. Winnecker.
4. “Gene Cloning “ by T. A. Brown

**Semester – 5**

**CC-BIOTECHNOLOGY-12**

**Paper: IN-BTY- 503**

**PLANT BIOTECHNOLOGY**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes**: On successful completion of the course the student will be able to

* 1. Elaborate the concept of plant tissue culture, totipotency, differentiation and somaclonal variation.
	2. Describe different techniques of micropropagation in plants, their applications and limitations.
	3. Give an insight of vector mediated and vectorless methods of plant cell transformation, along with merits and demerits.
	4. Correlate the plant genome organization with different types of transformations

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**UNIT I**

**Introduction:** Cryo and organogenic differentiation, Types of culture: Seed , Embryo, Callus, Organs, Cell and Protoplast culture. Micropopagation Axillary bud proliferation, Meristem and shoot tip culture, cud culture, organogenesis, embryogenesis, advantages and disadvantages of micropropagation

**In vitro haploid production:** Androgenic methods: Anther culture, Microspore culture andogenesis Sgnificance and use of haploids, Ploidy level and chromosome doubling, diplodization, Gynogenic haploids, factors effecting gynogenesis, chromosome elimination techniques for production of haploids in cereals.

**UNIT – II**

**Protoplast Isolation and fusion:** Methods of protoplast isolation, Protoplast development, Somatic hybridization, identifiation and selection of hybrid cells, Cybrids, Potential of somatic hybridization limitations.Somaclonal variation Nomenclautre, methods, applications basis and disadvantages.

**Organization of plant genome:** Nuclear, Chloroplast and Mitochondrial genome. Chloroplast Transformation- vector designing, methods and advantages. Plant Nuclear Transformation- Agrobacterium mediated transformation, Ti and Ri plasmids, role of virulence genes, mechanism of T-DNA transfer, vectors based on Ti and Ri plasmids, cointegrate and binary vectors, techniques and factors effecting Agrobacterium mediated transformation of plants.Direct gene transfer methods- particle bombardment, PEG-mediated, electroporation, microinjection and other alternative methods.

**Suggested Reading**

1. Bhojwani, S.S. and Razdan 2004 Plant Tissue Culture and Practice.
2. Brown, T. A. Gene cloning and DNA analysis: An Introduction. Blackwell Publication.
3. Gardner, E.J. Simmonns, M.J. Snustad, D.P. 2008 8th edition Principles of Genetics. Wiley India.
4. Raven, P.H., Johnson, GB.,Losos, J.B. and Singer, S.R. 2005 Biology. Tata MC Graw Hill.
5. Reinert, J. and Bajaj, Y.P.S. 1997 Applied and Fundamental Aspects of Plant Cell, Tissue and Organ Culture.Narosa Publishing House.
6. Russell, P.J. 2009 Genetics – A Molecular Approach. 3rdedition. Benjamin Co.
7. Sambrook&Russel. Molecular Cloning: A laboratory manual. (3rd edition)
8. Slater, A., Scott, N.W. & Fowler, M.R. 2008 Plant Biotechnology: The Genetic Manipulation of Plants, Oxford University Press.

**Semester – 5**

**CC-BIOTECHNOLOGY-12**

**Paper: IN-BTY - 504**

 **PLANT BIOTECHNOLOGY - PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes:** On successful completion of the course the student will be able to

* 1. Prepare and sterilize different media required for plant tissue culture
	2. Perform micro-propagation with different explants

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. Preparation of simple growth nutrient (Knop’s medium), full strength, half strength, solid and liquid.
2. Preparation of complex nutrient medium (Murashige & Skoog’s medium)
3. To selection, Prune, sterilize and prepare an explant for culture
4. Haploid culture: Andogenesis and Gynogenesis.
5. Protoplast isolation using enzymatic method.
6. Analysis of various plant extracts for their antibiotic activity.
7. Performance of node culture.
8. Suspension culture with different explants.
9. Embryo culture.
10. Transferring the grown plants to hardening medium.

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**Suggested Reading**

1. Bhojwani, S.S. and Razdan 2004 Plant Tissue Culture and Practice.
2. Reinert, J. and Bajaj, Y.P.S. 1997 Applied and Fundamental Aspects of Plant Cell, Tissue and Organ Culture.Narosa Publishing House.
3. Russell, P.J. 2009 Genetics – A Molecular Approach. 3rdedition. Benjamin Co.
4. Sambrook &Russel. Molecular Cloning: A laboratory manual. (3rd edition)

**Semester – V**

**DSE1-BIOTECHNOLOGY**

**Paper: IN-BTY-505**

**FOOD TECHNOLOGY**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes**: After the successful completion of the course the student will be able to

* 1. Gain the knowledge about different food and dietary supplements such as food from fungi, algae and bacteria and their large scale production and genetically modified (GM) foods.
	2. Learn about food additives & its classification and functions alongwith diverse methods of food preservation.
	3. Understand about various packing materials, their properties and functioning in food industries
	4. Learn the concept of safety, quality assurance and food adulteration along with the role of national and international food regulatory bodies their standards for maintaining food quality and safety.

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**Unit – 1**

**Foods and supplements:** Introduction to food technology- history, background, food compositions; Dietary supplements; Production of food from fungi, algae and bacteria: Single cell proteins (SCP), mushrooms (edible fungus) etc; fermented foods and beverages-Bread, coffee, cheese, butter, yoghurt, meat, fish, beer, wine etc; transgenic plant foods- carbohydrates, proteins, vitamins nutritional quality improvement of the food crops by genetic engineering; Food borne disease (brief)

**Food additives & preservation techniques:** Food additives- definitions, need for food additives, classification and functions of different additives: thickeners, antioxidants, coloring agents, flavoring agents, sweeteners, emulsifiers, flour improvers; Preservation techniques: techniques like refrigeration & freezing, dehydration, heating etc., antimicrobial agents used in food preservation.

**Unit –II**

**Food Packaging:** Introduction to Food Packaging: definition, factors involved in the evolution and selection of a food package, functions of food packaging. Types of packaging materials and their functioning properties; Aseptic packaging of foods: sterilization techniques of food and packaging material; Advantages and disadvantages associated with packaging of foods.

**Food Safety and Quality Control:** Introduction to concepts of food safety including safety of GM food crops and food quality assurance; Food adulteration, nature of adulterants, methods of evaluation of food adulterants and toxic constituents. Role of national and international regulatory agencies, Bureau of Indian Standards (BIS), AGMARK, Food Safety and Standards Authority of India (FSSAI), USFDA, International organization for standards (ISO) and its standards for food quality and safety (ISO 9000 series, ISO 22000, ISO 15161, ISO 14000).

**Suggested Readings:**

* Food Sciences and Food Biotechnology, Lopez GFP, Canas G, Nathan EV, CRC Publications
* Genetically Modified Foods; Ruse M, Castle D, Prometheus Book publication.
* Biotechnology and Food Process Engineering; Schwartzberg HG, Rao MA, Marcel Dekker.
* Modern Food Biotechnology; Jay JM, Lossner MJ, Golden DA.
* Food Science; Potter NN, Hotchkiss JH.
* Sivasankar,B (2002): Food Processing and Preservation, Prentice Hall of India Pvt.Ltd., New Delhi.
* Khetarpaul N. (2005).Food Processing and Preservation, Dya Publishing House, New Delhi.
* Robertson, G.L. (2006). Food Packaging: Principles and Practice (2nd ed.), Taylor and Francis
* Ahvenainen, R. (Ed.) Novel Food Packaging Techniques, CRC Press, (2003).
* Han, J.H.(Ed.) Innovations in Food Packaging, Elsevier Academic Press, (2005).
* Food and Agricultural Organization (1980): Manuals of Food Quality Control. 2 Additives Contaminants Techniques, Rome.
* Gould,W.A. and Gould, R.W. (1998). Total Quality Assurance for the Food Industries, CTI Publications Inc.Baltimore.
* Dietrich Knorr, Steven R. Tannebaum and Pieter Walstra.Food Biotechnology. Biotechnology group, Department of food and sciences, University of Delaware, New York Delaware.Marcel Dekker Inc. New Yorl and Baset.
* V.K. Josh (2009).Biotechnology; Food fermentation in Microbiology, Biochemistry and Technology, Vol. 1 and 2.

**Semester – V**

**DSE1-BIOTECHNOLOGY**

**Paper: IN-BTY-506**

**FOOD TECHNOLOGY- PRACTICALS**

**Credits: 2**

**Total Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Examination Time: 3 h**

**Learning Outcomes**: On successful completion of the course the student will be able to

**506.1** check the quality of packed and unpacked foods and role of preservation techniques

**506.2** characterize food samples for nutrients and adulterants

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. To study the various sterilization and food preservation techniques.
2. Determination of water vapour transmission rate for given packaging materials.
3. Determination of Acidity & pH in food sample/beverages.
4. Determination of total, non-reducing and reducing sugars in the given food sample.
5. To test the quality of milk (branded, non-branded and local) by Methylene Blue Reduction Test (MBRT) and other tests
6. Determination of adulterants in the given oil/milk/food samples

**Suggested Readings:**

* Sivasankar,B (2002): Food Processing and Preservation, Prentice Hall of India Pvt.Ltd., New Delhi.
* Khetarpaul N. (2005).Food Processing and Preservation, Dya Publishing House, New Delhi.
* Robertson, G.L. (2006). Food Packaging: Principles and Practice (2nd ed.), Taylor and Francis
* Ahvenainen, R. (Ed.) Novel Food Packaging Techniques, CRC Press, (2003).
* Han, J.H.(Ed.) Innovations in Food Packaging, Elsevier Academic Press, (2005).

**Semester – V**

**DSE1-BIOTECHNOLOGY**

**Paper: IN-BTY-507**

**BIOMATHEMATICS**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes**: After the successful completion of the course the student will be able to

* 1. Understand the basics of mathematics and its use in biological sciences.
	2. Learn about complex numbers and matrices which can help them to understand various biological models involving variables i.e. frequencies of multiple alleles, population dyanamics, image processing and bioinformatics etc.
	3. Learn about differential equation and its application which can be used in modeling.
	4. Gain knowledge related to partial differential equations which help them to understand regulatory feedbacks and transport processes in multicellular biological systems

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**Unit I**

**Complex Numbers**: Introduction, Operations on complex numbers, Complex conjugate, Modules and argument of complex number and simple examples on it.,.4 DE MOIVRE’S Theorem., Simple examples on above theorem ,th n roots of a complex number and simple examples on it.

**Matrices:** Definition and types of Matrices, Algebra of Matrices (addition, subtraction, scalar multiplication and multiplication of matrices), Examples on operation of Matrices, Inverse of a matrix by a ad joint method, Rank of a Matrix (Definition) and examples, System of Linear equation, Non homogenean, Homogenean with examples, Eigen values and eigen vectors with simple examples

**Unit II**

**Differential equation:** Definition of ordinary differential equation and degree, order of differential equation Exact differential equation with simple examples, Linear differential equation dy/dx+py =Q method of solution with simple examples. Bernoulli’s differential equation with examples, Application of differential equation i) Growth and decay problems ii) Newton’s law of cooling with examples.

**Partial differentiation:** Introduction, Simple examples on evaluation of partial derivatives, Composite function with examples, Homogenous function (Definition), Euler’s theorem for first and second order., Simple examples on above theorems., Extreme values with examples., Lagrange’s method of undetermined multipliers (with proof), Examples on above method.

**Suggested reading:**

1. Partial Differential Equation by IN Sneiden
2. Matrices by Shanti Narayan
3. Complex Variables by Shanti Narayan
4. Ordinary Differential Equation by Saplay & Ross

**Semester – V**

**DSE1-BIOTECHNOLOGY**

**Paper: IN-BTY-508**

**BIOMATHEMATICS-PRACTICALS**

**Credits: 2**

**Total Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Examination Time: 3 h**

**Learning Outcomes**: On successful completion of the course the student will be able to

**508.1** Apply operation on complex number and matrices

**508.2** Apply composite functions and differential equation

**Approaches to teaching**

Instructions, Chalk and board teaching, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. Exercises on Operations on complex numbers and theorems,
2. Exercises on operation of Matrices, Inverse of a matrix and ad joint method
3. Exercises on Rank of a Matrix: System of Linear equation, Non homogenean, Homogenean, Eigen values and Eigen vectors
4. Exercises based on ordinary differential equation and Linear differential equation
5. Examples on evaluation of partial derivatives, Composite function, Homogenous function
6. Application of differential equation i) Growth and decay problems ii) Newton’s law of cooling, Extreme value, Lagrange’s method of undetermined multipliers

**Semester – V**

**DSE2-BIOTECHNOLOGY**

**Paper: IN-BTY-511**

**MEDICAL BIOTECHNOLOGY**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes**: After the successful completion of the course the student will be able to

511.1 Understand chromosomal, gene and mitochondrial disorders and will describe about various biotechnology tools to detect these disorders.

511.2 Learn about various invasive and non-invasive techniques to diagnose human disorders during prenatal period.

511.3 Understand metabolic disorders and their management by using diverse therapeutic approaches.

511.4 Describe and appraise broad knowledge of the use of gene products as vaccines

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**Unit I**

**Classification of genetic diseases:**

Chromosomal disorders – Numerical disorders e.g. trisomies & monosomies; Structural disorders - deletions, duplications, translocations & inversions; Chromosomal instability syndromes. Gene controlled diseases – Autosomal and X-linked disorders, Mitochondrial disorders and Multifactorial conditions. Identification of disease genes, Functional cloning –haemophilia gene. Positional cloning - DMD and CGD genes. Candidate gene approach –Marfan’s syndrome, Alzheimer’s disease.

**Molecular basis of human diseases** - Pathogenic mutations. Gain of function mutations: Oncogenes, Huntingtons Disease, Pittsburg variant of alpha 1 antitrypsin. Loss of function - Tumour Suppressor Genes, PAX- 3 gene; Gene Dosage Effect - PMP22 , Collagen gene; Genomic Imprinting -Mechanisms, Praderwilli / Angelman syndrome, WAGR syndrome, Beckwith Weidemann Syndrome; Dynamic Mutations - Fragile- X syndrome, Myotonic dystrophy; Mitochondrial diseases: MELAS, LHON

Autoimmune Disorders-SLE, RA

**Diagnostics**

Prenatal diagnosis - Invasive techniques - Amniocentesis, Fetoscopy, Chorionic Villi Sampling (CVS), Non-invasive techniques - Ultrasonography, X-ray, TIFA, maternal serum and fetal cells in maternal blood; Diagnosis using protein and enzyme markers, monoclonal antibodies. DNA/RNA based diagnosis Microarray technology- genomic and c DNA arrays, application to diseases

**Unit II**

**Therapeutics**

Clinical management and Metabolic manipulation - PKU, Familial Hypercholesterolemia, Rickets, ADA, Congenital hypothyroidism; Gene therapy: Ex-vivo, Invivo, Insitu gene therapy, Strategies of gene therapy: gene augmentation – ADA defeiciency, CFTR Prodrug therapy/ suicide gene – glioma, evoking immune response – melanoma TFO, Antisense therapy, Ribozymes, Protein Aptamers, Intrabodies

**Vectors used in gene therapy**: Biological vectors – retrovirus, adenoviruses, Herpes Synthetic vectors– liposomes, receptor mediated gene transfer; Gene therapy trials – Familial Hypercholesterolemia, Cystic Fibrosis, Solid tumours. Cell and tissue engineering: Encapsulation technology and therapeutics - Diabetes, Hypothyroidism, Haemophilia Bioartificial organs, Artificial Cells- For Haemophilia, Phenylkeptonuria

**Gene products in medicine**: Functional cloning – anti-haemophilic factor; Positional cloning- Dystrophin; Gene products in medicine - Humulin, Erythropoietin, Growth Hormone/Somatostatin, tPA, Interferon; DNA based vaccines; Vector vaccines – Cholera and Salmonella; Attenuated Vaccines– Cholera

**Semester – V**

**DSE2-BIOTECHNOLOGY**

**Paper: IN-BTY-512**

**MEDICAL BIOTECHNOLOGY-PRACTICALS**

**Credits: 2**

**Total Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Examination Time: 3 h**

**Learning Outcomes**: On successful completion of the course the student will be able to

**512.1** analyse DNA damage and modifications

**512.2** give an insight of development of disease causing agents and diagnostic tools

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. Single Cell Gel Electrophoresis to detect DNA damage
2. Perform immunoelectrophoresis
3. Perform DNA fingerprinting analysis
4. Determine TLC and DLC in human blood smear.
5. Determine mutation by AIMS test
6. Illustrate about artificial cells and organs.
7. Illustrate the formation of Adenoviruses/Retroviruses.
8. Illustrate about the invasive and non-invasive diagnostic tools

**DSE2-BIOTECHNOLOGY Paper** IN-BTY-513,IN-BTY-514, IN-BTY-515 and IN-BTY-516 will be same as B-CHEM-301**,** B-CHEM-302, B-CHEM-303 and B-CHEM-304 approved by UG-BOS, Department of Chemistry, KUK

**Semester – V**

**GE-ZOOLOGY-5**

**Paper: IN-ZOO-501**

**EVOLUTIONARY BIOLOGY**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes**: After the successful completion of the course the student will be able to

**501.1** Understand the conditions conducive for origin of life on earth and also about various theories related to origin of life and evolutionary biology.

**501.2** Differentiate between micro, macro and mega evolution and will understand interrelation amongst various species and can develop the phylogeny trees accordingly

**501.3** Explain the concept of variations in the species and will describe about the population genetics and role of migration and mutation in the evolution

**501.**4 Understand the concept of selection, types and their impact on evolution

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**Unit-1**

* Origin of life.
* Concept and evidences of organic evolution.
* Theories of organic evolution.
* Concept of micro, macro-and mega-evolution.
* Phylogeny of horse.
* Phylogeny of man.

**Unit-2**

* Variations
* Population genetics: Gene pool, gene frequency, Hardy-Weinberg Law, Genetic Drift, founder’s effect, bottleneck phenomenon; Role of Migration and Mutation in evolution
* Natural selection, sexual selection
* Isolation
* Speciation
* Concept of species

**Suggested readings:**

* Cell Biology, Genetics, Molecular Biology, Evolution & Ecology by Verma and Aggarwal
* Organic evolution by Veer BalaRastogi

**Semester – V**

**GE-ZOOLOGY-5**

**Paper: IN-ZOO-502**

**EVOLUTIONARY BIOLOGY: PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes:** After successful completion of this course students will be able to

**502.1** Understand the process of adaptations and variations

**502.2** Identify fossils

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. To study beaks and feet of birds
2. To study fossils from photographs
3. To study living fossil from specimens
4. To monitor human height, weight and BMI
5. To monitor discrete characteristics i.e. tough rolling, air lobe etc.

**Semester – 6**

**CC-BIOTECHNOLOGY-13**

**Paper: IN-BTY- 601**

**GENOMICS & PROTEOMICS**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes:** Students who successfully complete this course will be able to

* 1. Determine the function of genes and elements that regulate genes throughout the genome and apply sequence for analysis of organism genome.
	2. Perform on various web based softwares for genome analysis
	3. Correlate the findings of protein techniques to the structures of proteins
	4. Analyse proteomes using various tools and techniques

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**UNIT I**

Introduction to Genomics, DNA sequencing methods – manual & automated: Maxam& Gilbert and Sangers method. Pyrosequencing, Genome Sequencing: Shotgun & Hierarchical (clone contig) methods,

Computer tools for sequencing projects: Genome sequence assembly software.

Managing and Distributing Genome Data: Web based servers and softwares for genome analysis: ENSEMBL, VISTA, UCSC Genome Browser, NCBI genome. Selected Model Organisms' Genomes and Databases.

**UNIT II**

Introduction to protein structure, Chemical properties of proteins.Physical interactions that determine the property of proteins. Short-range interactions, electrostatic forces, van der waal interactions, hydrogen bonds, Hydrophobic interactions.

Determination of sizes (Sedimentation analysis, gel filteration, SDS-PAGE); Native PAGE, Determination of covalent structures – Edman degradation.

Introduction to Proteomics, Analysis of proteomes.2D-PAGE.Sample preparation, solubilization, reduction, resolution.Reproducibility of 2D-PAGE. Mass spectrometry based methods for protein identification. De novo sequencing using mass spectrometric data.

**SUGGESTED READING:**

1. Genes IX by Benjamin Lewin, Johns and Bartlett Publisher, 2006.
2. Modern Biotechnology, 2nd Edition, S.B. Primrose, Blackwell Publishing, 1987.
3. Molecular Biotechnology: Principles and Applications of Recombinant DNA, 4th Edition, B.R. Glick, J.J. Pasternak and C.L. Patten, 2010.
4. Molecular Cloning: A Laboratory Manual (3rd Edition) Sambrook and Russell Vol. I to III, 1989.
5. Principles of Gene Manipulation 6th Edition, S.B.Primrose, R.M.Twyman and R.W. Old. Blackwell Science, 2001.
6. Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics.IX Edition. Benjamin Cummings. 4. Russell, P. J. (2009). iGenetics- A Molecular Approach. III Edition. Benjamin Cummings.
7. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
8. Pevsner, J. (2009). Bioinformatics and Functional Genomics.IIEdition.John Wiley & Sons.

**Semester – VI**

**CC-BIOTECHNOLOGY-13**

**Paper: IN-BTY- 602**

**GENOMICS & PROTEOMICS - PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes:** Students who successfully complete this course will be able to

* 1. Perform on various databases of genome analysis.
	2. Perform on various tools of proteome analysis.

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; computers, Internet facility; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**PRACTICALS:**

1. Use of SNP databases at NCBI and other sites
2. Use of OMIM database
3. Detection of Open Reading Frames using ORF Finder
4. Proteomics 2D PAGE database
5. Softwares for Protein localization.
6. Hydropathy plots
7. Native PAGE
8. SDS-PAGE

**SUGGESTED READINGS:**

1. Genes IX by Benjamin Lewin, Johns and Bartlett Publisher, 2006.
2. Modern Biotechnology, 2nd Edition, S.B. Primrose, Blackwell Publishing, 1987.
3. Molecular Biotechnology: Principles and Applications of Recombinant DNA, 4th Edition, B.R. Glick, J.J. Pasternak and C.L. Patten, 2010.
4. Molecular Cloning: A Laboratory Manual (3rd Edition) Sambrook and Russell Vol. I to III, 1989.
5. Principles of Gene Manipulation 6th Edition, S.B.Primrose, R.M.Twyman and R.W. Old. Blackwell Science, 2001.
6. 6.Klug, W.S., Cummings, M.R., Spencer, C.A. (2009). Concepts of Genetics.IX Edition. Benjamin Cummings. 4. Russell, P. J. (2009). iGenetics- A Molecular Approach. III Edition. Benjamin Cummings.
7. Glick, B.R., Pasternak, J.J. (2003). Molecular Biotechnology- Principles and Applications of recombinant DNA. ASM Press, Washington.
8. Pevsner, J. (2009). Bioinformatics and Functional Genomics.IIEdition.John Wiley & Sons.

**Semester – 6**

**CC-BIOTECHNOLOGY-14**

**Paper: IN-BTY- 603**

**IPR, BIOETHICS AND BIOSAFETY**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

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**Learning Outcomes:** Students who successfully complete this course will be able to

* 1. Learn the concept of Intellectual property rights, national institutes belonging to the IPRs, patent laws, IPR’s regulatory affairs and their applications in modern world and also will understand about commercialization of inventions in the biotechnology sector
	2. Understand about start-ups and business strategies by taking account of IPRs and will gain the importance of innovative research.
	3. Understand the concepts, its laws and the importance of regulatory bodies in bioethics and will describe about ethical practices appropriate to the scientific disciplines at all times.
	4. Gain the concept about the biosafety, its levels and government guidelines while working with microorganisms, animal blood/tissue/cells, other hazardous & non-hazardous samples and will understand about other safe working practices relevant to the fields of research & different biotechnology industries.

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**UNIT-I**

**Intellectual property rights**: General Introduction to intellectual property rights and its different forms. Farmers Rights, Animal and Plant breeders rights. Development of patent system in India. WTO agreement and TRIPS Patent Cooperation treaty, Basic requirements of patentability, patentable subject matter, novelty and the Public Domain; Non obviousness Compulsory licensing, Patent infringements and revocation. Special issues in Biotechnology Patents: Disclosure Requirements, Collaborative research, competitive research, Patent Litigation: Recent Development in Patent System; Patentability of Biotechnology invention and its commercialization, Budapest treaty.

**Entrepreneurship**: Selection of a product, line, design and development processes, economics on material and energy requirement, stock the product and release the same for making etc. The basic regulations of excise: Demand for a given product, feasibility of its production under given constraints of raw material, energy input, financial situations export potential etc.Innovation & Start-ups.

**UNIT-II**

**Bioethics** – Necessity of Bioethics, different paradigms of Bioethics – National & International. Ethical issues against the molecular technologies

**Biosafety**: Introduction; Historical Background; Introduction to Biological Safety Cabinets; Primary

Containment for Biohazards; Biosafety Levels; Biosafety Levels of Specific Microorganisms; Recommended Biosafety Levels for Infectious Agents and Infected Animals; Biosafety guidelines - Government of India; Definition of GMOs & LMOs; Roles of Institutional Biosafety Committee, RCGM, GEAC for GMO applications in food and agriculture; Environmental release of GMOs; Risk Analysis; Risk Assessment; Risk management and communication. Brief account of bioethics in Biotechnology

**Suggested Readings:**

1. Elements of Biotechnology; Gupta PK, Rastogi Publications, Meerut.
2. Intellectual Property rights in the WTO and Developing countries; Watal J, Oxford
3. Entrepreneurship: New Venture Creation : David H. Holt
4. Patterns of Entrepreneurship : Jack M. Kaplan
5. Entrepreneurship and Small Business Management: C.B. Gupta, S.S. Khanka, Sultan Chand & Sons.
6. Sateesh MK (2010) Bioethics and Biosafety, I. K. International Pvt Ltd. 5. Sree Krishna V (2007) Bioethics and Biosafety in Biotechnology, New age international publishers

**Semester – 6**

**CC-BIOTECHNOLOGY-14**

**Paper: IN-BTY- 604**

**IPR, BIOETHICS AND BIOSAFETY-PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes:** Students who successfully complete this course will be able to

* 1. Demonstrate the knowledge of the intellectual property rights and its utility in the securing inventor’s rights against new innovation and in initiating start-ups
	2. Exhibits skill when and how to handle biological and non-biological; hazardous and non-hazardous samples

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; computers, Internet Facility

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals**

1. Proxy filing of Indian Product patent
2. Proxy filing of Indian Process patent
3. Planning of establishing a hypothetical biotechnology industry in India
4. A case study on clinical trials of drugs in India with emphasis on ethical issues.
5. Case study on women health ethics.
6. Case study on medical errors and negligence
7. Case study on handling and disposal of radioactive waste

**Suggested Readings:**

1. Elements of Biotechnology; Gupta PK, Rastogi Publications, Meerut.
2. Intellectual Property rights in the WTO and Developing countries; Watal J, Oxford
3. University Press.
4. Intellectual Property Bulletin, New Delhi

**Semester – VI**

**DSE3-BIOTECHNOLOGY**

**Paper: IN-BTY-605**

**IMMUNOLOGY**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes**: After the successful completion of the course the student will be able to

* 1. Exhibit the knowledge of basic components, organs, cells of immune system, components of immunity and will understand the coordination between humoral, cell-mediated and innate immune responses in combating pathogens.
	2. Illustrate the attributes of antigens, immunogens, factors affecting immunogenicity; the structure and functions of different types of immunoglobulins.
	3. Explain the mechanisms generating diversity and specificity in immune system alongwith principles and applications of several immunotools (RIA, ELISA, FACS etc) which can be used to quantify the interaction between antigen and antibody of the immune system.
	4. Describe about the immunonization, role of vaccines against complex disorders and will also understand the concept of immune tolerance, immunosupression and immune responses to infectious diseases.

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**Unit I**

**Introduction to immune system**: Memory, specificity, diversity, innate and acquired immunity, self vs non-self-discrimination, structure and functions of primary and secondary lymphoid organs

Cells involved in immune responses: Phagocytic cells and their killing mechanisms; T and B lymphocytes, differentiation of stem cells and idiotypic variations

Nature of antigen and antibody: Antigens vsimmunogen, haptens, structure and functions of immunoglobulins; isotypic, allotypic and idiotypic variations

**Humoral and cell mediated immune responses**: kinetics of primary and secondary immune responses, complement activation and its biological consequences, antigen processing and presentation, cytokines and costimulatory molecules- role in immune responses, T and B cell interactions.

**Major Histocompatibility Complex (MHC) genes and products:** polymorphism of MHC genes, role of MHC antigens in immune responses, MHC antigens in transplantation

**Unit II**

**Generation of diversity in immune system:** Clonal selection theory- concept of antigen specific receptor, organization and expression of immunoglobulin genes- generation of antibody diversity, T-cell receptor diversity.

**Measurement of antigen –antibody interaction:** Production of polyclonal and monoclonal antibodies- principles, techniques and applications; Agglutination and precipitation techniques; Radio immunoassay; ELISA; Immunofluorescence assays- Fluorescence activated cell sorter (FACS) technique.

**Immunization:** Active & passive immunization, vaccines and their types, role of vaccines in the prevention of diseases

**Tolerance vs activation of immune system:** Immune tolerance, immunosuppression, hypersensitivity (Types I, II, III and IV).

**Immune responses in diseases:** Immune responses to infectious diseases- viral, bacterial and protozonal; cancer and immune system, immunodeficiency disorders and autoimmunity

**Suggested Reading:**

1. Immunology, 4th ed. by Roitt et al., Mosby Publications
2. Cellular and Molecular Immunology, 5th ed. by Abbas and Litchman (2003), Saunders Publication.
3. Kuby Immunology, 4rd ed. by R.A. Goldsby et al, W.H. Freeman & Co.
4. Immunology: an introduction, 4th Edition by Ian R Tizard, (1995), Saunders College Publishing

**Semester – VI**

**DSE3-BIOTECHNOLOGY**

**Paper: IN-BTY-606**

**IMMUNOLOGY-PRACTICALS**

**Credits: 2**

**Total Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Examination Time: 3 h**

**Learning Outcomes**: On successful completion of the course the student will be able to

**606.1** perform various immunoassays such as Radial immunoassay FACS

**606.2** separate and quantify proteins from blood/serum/ plasma samples

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. To identify blood group
2. To estimate Hb by cyan-meth hemoglobin method
3. To isolate -globulins by ammonium sulfate fractionation
4. To separate globulins and estimate albumin globulin ratio in blood
5. Separation of serum and plasma from the blood sample
6. Perform gel electrophoresis (PAGE) by using serum and plasma samples
7. Radial immunoassay
8. Demonstration of FACS

**Semester – VI**

**DSE3-BIOTECHNOLOGY**

**Paper: IN-BTY-607**

**BIOINFORMATICS**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes**: After the successful completion of the course the student will be able to

* 1. Understand the fundamentals, importance and limitation of bioinformatics and biological databases.
	2. Describe the concept of sequence alignment, its types and importance of scoring matrices and will understand about bioinformatics tools such as BLAST, FASTA, clustal-w etc. that will help in generating accurate prediction about gene and its product.
	3. Learn about molecular phylogenetic tools which will help to depict the probable evolution of various organisms by building a "relationship tree".
	4. Learn about biological macromolecular structures and structure prediction methods.

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**Unit I**

Bioinformatics and biological databases: Introduction, application and limitation to bioinformatics; introduction, classification and pitfalls of biological databases, Biological data formats, Introduction to single letter code of aminoacids, symbols used in nucleotides, data retrieval- Entrez and SRS.

Sequence alignment: Substitution matrices, Scoring matrices – PAM and BLOSUM. Local and Global alignment concepts, Dot plot. Dynamic programming methodology: Needleman and Wunsch algorithm. Smith–Waterman algorithm. Statistics of alignment score.

Multiple sequence alignment.Progressive alignment.Database search for similar sequences using FASTA and BLAST Programs. Evolutionary analysis: distances, Cladistic and Phenetic methods. Clustering Methods. Rooted and unrooted tree representation. Bootstrapping strategies, Use of Clustal and PHYLIP.

**Unit II**

Molecular Phylogenetics:Molecular Evolution, Gene Phylogeny versus Species Phylogeny, Forms of Tree Representation, Phylogenetic Tree Evaluation, Phylogenetic Programs

Distance-Based Methods, Character-Based Methods,

Gene finding methods. Gene prediction: Analysis and prediction of regulatory regions. Fragment assembly. Genome sequence assembly, Restriction Mapping, Repeat Sequence finder.

Structural Bioinformatics:Concepts of secondary structure prediction of RNA and Protein. Probabilistic models: Markov chain, Hidden Markov Models-other applications.

**Suggested reading:**

* Bioinformatics – Concepts, Skills, Applications”. S.C. Rastogi, NamitaMendiratta, ParagRastogi.
* Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. Andréa’s D. Baxevanis, B.F. Francis Ouellette.
* Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids. Richard Durbin et al.
* Computer Methods for Macromolecular Sequence Analysis. Doolittle R.F. (Ed.) (Methods in Enzymology, Vol. 266).
* Shanmughavel, P. 2005. Principles of Bioinformatics, Pointer Publishers, Jaipur, India.
* DNA and Protein Sequence Analysis. A Practical approach. Bishop M.J.Rawlings C.J. (Eds.).
* Introduction to Bioinformatics. Teresa. K. Atwood and David J. Parry-Smith.
* (http://www.imtech.res.in/raghava/gpsr/).

**Semester – VI**

**DSE3-BIOTECHNOLOGY**

**Paper: IN-BTY-608**

**BIOINFORMATICS-PRACTICALS**

**Credits: 2**

**Total Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Examination Time: 3 h**

**Learning Outcomes**: On successful completion of the course the student will be able to

**608.1** search, use and download various biological database

**608.2** perform prokaryotic, eukaryotic gene analysis: prosite, motif and rna structure prediction

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. Types & Examples of Biological Databases (Primary and Secondary), their URLs and Major functions.
2. NCBI (PubMed, Nucleotide): Literature search and Data retrieval. (How to do literature search using NCBI’s PubMed & Data retrieval of a gene using NCBI’s Nucleotide database).
3. Download Human Haemoglobin gene from NCBI database in GenBank and FASTA format.
4. Using NCBI Nucleotide database, search and download FASTA file of a Human gene (e.g. BRCA1), run BLAST at NCBI website.
5. Global alignment: Make scoring matrix of these two sequences, ACGGCTC & ATGGCCTC using values as match= +1, mismatch= -3, gap penality= -4.
6. How to run BLAST software (Nucleotide BLAST, blastx, tblastn, Protein BLAST) and their uses.
7. Run ClustalW for Multiple sequence alignment of three human proteins.
8. Phylogenetic tree construction using PHYLIP program.
9. Prokaryotic gene finding using GLIMMER, Eukaryotic by GENSCAN program.
10. Major steps of Eukaryotic Genome Assembly (Whole Genome Assembly).
11. Protein structure prediction by HMM profile (sequence) based method.
12. To perform prosite for domain perdiction
13. To perform Pfam for motif prediction
14. To perform RNA FOLD for rna structure prediction
15. To perform jpred
16. To perform GENSCAN

**Semester – VI**

**DSE4-BIOTECHNOLOGY**

**Paper: IN-BTY-609**

**MOLECULAR DIAGNOSTICS**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes**: After the successful completion of the course the student will be able to

* 1. Know about uses of enzymes and antibodies (monoclonal & polyclonal) for diverse immunooassays and their applications in medical diagnostic purpose
	2. Gain the knowledge of various molecular approaches (PCR, RFLP etc) and chemotherapy tests which can be used in clinical testing.
	3. Explain about automation in microbial diagnosis and other rapid diagnostic approaches based on the concept of idiotypes.
	4. Describe and appraise various diagnostic tools which can help to study in details about cell biology such as RIA, immunoflorescence, chromatrography, microscopy etc and associated with medical science.

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**UNIT I**

**Enzyme Immunoassays**: Comparison of enzymes available for enzyme immunoassays, conjugation of enzymes. Solid phases used in enzyme immunoassays. Homogeneous and heterogeneous enzyme immunoassays.Enzyme immunoassays after immuno blotting.

**Enzyme immuno histochemical techniques**: Use of polyclonal or monoclonal antibodies in enzymes immuno assays. Applications of enzyme immunoassays in diagnostic microbiology; Molecular methods in clinical microbiology: Applications of PCR, RFLP, Nuclear hybridization methods, Single nucleotide polymorphism and plasmid finger printing in clinical microbiology

**Laboratory tests in chemotherapy**: Susceptibility tests: Micro-dilution and macro-dilution broth procedures. Susceptibility tests: Diffusion test procedures. Susceptibility tests: Tests for bactericidal activity. Automated procedures for antimicrobial susceptibility tests.

**UNIT II**

**Automation and rapid diagnostic approach**: Automation in microbial diagnosis, rapid diagnostic approach including technical purification and standardization of antigen and specific antibodies.

**Idiotypes and immunodiagnostic:** Concepts and methods in idiotypes. Antiidiotypes and molecular mimicry and receptors.Epitope design and applications.Immunodiagnostic tests- Immuno florescence.Radioimmunoassay.

**Diagnostic tools:** GLC, HPLC, Electron microscopy, flow cytometry and cell sorting.

**SUGGESTED READING**

1. Practical Biochemistry, Principles and Techniques, Keith Wilson and John Walker

2. Bioinstrumentation, Webster

3. Advanced Instrumentation, Data Interpretation, and Control of Biotechnological Processes, J.F. Van Impe,Kluwer Academic

4. Ananthanarayan R and Paniker CKJ. (2005). Textbook of Microbiology.7th edition (edited by Paniker CKJ).University Press Publication.

5. Brooks GF, Carroll KC, Butel JS and Morse SA.(2007). Jawetz, Melnick and Adelberg’s Medical Microbiology.24th edition.McGraw Hill Publication.

6. Goering R, Dockrell H, Zuckerman M and Wakelin D. (2007). Mims’ Medical Microbiology.4th edition.Elsevier.

7. Joklik WK, Willett HP and Amos DB (1995). Zinsser Microbiology.19th edition.AppletonCentuary-Crofts publication.

8. Willey JM, Sherwood LM, and Woolverton CJ.(2008). Prescott, Harley and Klein’s Microbiology.7th edition.McGraw Hill Higher Education.

9. Microscopic Techniques in Biotechnology, Michael Hoppert

**Semester – VI**

**DSE4-BIOTECHNOLOGY**

**Paper: IN-BTY-610**

**MOLECULAR DIAGNOSTICS-PRACTICALS**

**Credits: 2**

**Total Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Examination Time: 3 h**

**Learning Outcomes**: On successful completion of the course the student will be able to

**610.1** use different diagnostic tools like Immunobloting, PCR, PAGE etc.

**610.2** quantify cells by cytometry, nucleic acid by southern hybridization and determine MIC

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. Perform Immunoblotting by using housekeeping gene product
2. Perform Nucleic acid based PAGE
3. Perform Column Chromatography (any) and demonstrate about GLC/HPLC.
4. Perform PCR based diagnosis of human/plant pathogen
5. Perform Rapid Diagnostic Assay (as per availability)
6. Determination of MIC of streptomycin against *E.coli* by broth method
7. Demonstrate Nucleic acid labeling and Southern Hybridization
8. Demonstrate flow cytometery

**DSE4-BIOTECHNOLOGY Paper** IN-BTY-611,IN-BTY-612, IN-BTY-613 and IN-BTY-614 will be same as B-CHEM-401**,** B-CHEM-402, B-CHEM-403 and B-CHEM-404 approved by UG-BOS, Department of Chemistry, KUK

**Semester – VI**

**GE-ZOOLOGY-6**

**Paper: IN-ZOO-601**

**ECOLOGY AND ENVIRONMENT MANAGEMENT**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes**: After the successful completion of the course the student will be able to

**601.1** Understand the basic concepts of ecology and will describe about various factors including abiotic and biotic which affect environment.

**601.2** Describe about ecosystem, ecological energetic, energy flow and biogeochemical cycles.

**601.3** Explain about the biodiversity conservation of natural resources and population ecology

**601.4** Understanddifferent types of pollution, impact on environment and their management strategies.

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**Unit-I**

**Basic concepts of ecology**: Definition, signification. Concepts of habitat and ecological Niche.

**Factors affecting environment**: Abiotic factors (light-intensity, quality and duration), temperature, humidity, topography; edaphic factors; Biotic factors.

Introduction to major ecosystemt of the world.

**Ecosystem:** Concept, components, properties and functions; Ecological energetics and energy flow-food chain, food web, trophic structure; ecological pyramids concept of productivity.

**Biogeochemical cycles:** Concept, reservoir pool, gaseous cycles and sedimentary cycles.

**Unit-II**

Concept of biodiversity and conservation of natural resources.

**Population**: Growth and regulation.

**Population interactions:** Competition, predation, parasitism, commensalisms and mutualism.

**Environmental pollution:** Soil, Water, Air, radiation, landscape, noise

Detection of Environmental pollutant. Hazardous wastes Environmental cleanup Bioremediation, Waste disposal.

**Semester – VI**

**GE-ZOOLOGY-6**

**Paper: IN-ZOO-602**

**ECOLOGY AND ENVIRONMENT MANAGEMENT: PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes:** After successful completion of this course students will be able to

**602.1** Measure various physio-chemical parameters of water samples

**602.2** Document biodiversity

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. Chemical analysis of pond and soil ecosystem for pH,
2. Chemical analysis of pond and soil ecosystem for dissolved oxygen, BOD
3. Chemical analysis of pond and soil ecosystem for free CO2
4. Chemical analysis of pond and soil ecosystem for Nitrates, phosphates and chlorides
5. To study the diversity of vertebrates/ invertebrates in the campus

**Programme Outcomes for PG courses of Faculty of Life Sciences**

**PO1**: To acquaint students with recent knowledge and techniques in basic and applied biological sciences.

**PO2**: To develop understanding of organismal, cellular, biochemical and environmental basis of life

**PO3**: To provide insight into ethical implications of biological research for environmental protection and good laboratory practices and biosafety.

**PO4**:To develop problem solving innovative thinking with robust communication and writing skills in youth with reference to biological ,environmental and nutritional sciences.

**PO5:** To understand application of biotic material in health , medicine, food security for human well being and sustainable development.

**PO6**:To impart practical and project based vocational training for preparing youth for a career in research and entrepreneurship in fields of life sciences for self reliance.

**Programme specific Outcomes for PG courses in Biotechnology**

After the successful completion of the programme the student will be able to

**PSO1**: acquaint with theoretical and practical knowledge in different areas of Biotechnology. They will be able to understand various biological aspects and will develop into Biotech savvy integrated personalities with scientific thinking.

**PSO2**: analyse , solve problems related to Biotechnology fields. They will be able to launch startups, become entrepreneurs for novel biotechnology products and processes in various industries

**PSO3**: understand biosafety measures, ethical issues and regulatory compliances in Biotechnolgy

**PSO4**: communicate effectively, work independently, imbibe the values of team spirit, write execute and manage their research project.

**Semester-7**

**CC-BIOTECHNOLOGY-15**

**Paper: IN-BTY- 701**

**ADVANCED MOLECULAR BIOLOGY**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes:** Students who successfully complete this course will be able to

* 1. Understand the concepts of gene regulation in prokaryotes, the importance of E. coli lac & trp operon models along with gene expression regulation in lamda phages
	2. Learn about diverse regulatory sequences, transcriptional, post-transcriptional, translational and post-translation regulations in eukaryotes
	3. Describe the concept of transposable elements and their role in living systems including in viruses and will understand about RNAs world which includes siRNAs & miRNAs and their potential as a gene silencing and therapeutic agent
	4. Explain types of cancer, cancer causing agents, proto-oncogenes and mechanism for the activation of proto-oncogenes into oncogenes.

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**UNIT-I**

**Gene regulation in prokaryotes:** Inducer, repressor, co-repressor and activator concept,

+vely and –vely regulated genes, description of various levels of control of gene expression in prokaryotes, operon concept, lac operon: regulation by +ve and –ve mechanisms, trp operon: regulation by -ve and attenuation mechanisms, regulon, regulation of gene expression in lambda phages.

**Gene regulation in eukaryotes:** Regulatory sequences in eukaryotes like promoter,

enhancers, response elements, insulators and silencers, short-term and long term regulation of gene expression, molecular aspects of regulation of gene expression at transcription level like transcription repression by nucleosomes, histone modification by ubiquitination, acetylation, and phosphorylation, at post-transcriptional level like regulation of RNA splicing, RNA transport, RNA stability, at translational, post-translational and protein degradation level in eukaryotes.

**UNIT-II**

**Transposable genetic elements:** Discovery, mechanism of nonreplicative and replicative transposition, bacterial transposable genetic elements: simple transposons, complex transposons- the composite family and Tn3 transposon family and mechanisms of transposition, bacteriophage Mu elements. Eukaryotic transposable genetic elements – Ty elements of yeast, various autonomous and non autonomous elements of maize and mechanism of transposition.

**RNA world:** RNA world hypothesis, messenger RNA (mRNA), transfer RNA (tRNA), ribosomal RNA (rRNA), antisense RNA, RNA as an Enzyme, as a regulator. MicroRNA (miRNA)- History of microRNA, definition, composition, Dicer, RNA induced silencing complex (RISC), modern concepts on their roles in translation inhibition. Small interfering RNA or silencing RNA (siRNA) - History of siRNA, composition and

structure, roles in post-transcriptional gene silencing and potential as therapeutics

**Molecular Biology of Cancer:** Benign and malignant tumors, types of cancers, cancer causing agents- radiations, chemical compounds, DNA and RNA viruses, mechanism of carcinogenesis, important characteristics of cancerous cells, proto-oncogenes and oncogenes, promoter insertion, enhancer insertion, chromosomal translocation, gene amplification and point mutation as mechanism for activation of proto-oncogenes.

**Suggested Readings:**

* + 1. he Biochemistry of the Nucleic Acids; Adams RLP, Knowler JT and Leader DP,
1. Chapman and Hall Publication.
2. Genetics; Peter JR and Benjamin S, Cummings Publication.
3. Recombinant DNA; Watson JD, Tooze T, Kurtz DT, Scientific American Books.
4. Principles of Gene Manipulation; Old RW and Primose SB. Blackwell Scientific
5. Publication.
6. Molecular Biotechnology; Glick and Pasternack, ASM press.

**Semester – VII**

**CC-BIOTECHNOLOGY-15**

**Paper: IN-BTY- 702**

**ADVANCED MOLECULAR BIOLOGY-PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes:** After successful completion students will be able to

* 1. Isolate, quantify and analyze plant histone proteins using various techniques including microscopy & electrophoresis
	2. Use diverse online tools to explore promoter sequences in given prokaryotic/ eukaryotic genes

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals**

1. Isolation and quantification of Histone proteins from dark-grown wheat coleoptiles.
2. Separation of various Histone proteins using denaturing PAGE.
3. Finding promoter sequence of given animal gene and determining its sequence elements using tools like CISTER.
4. Finding promoter sequence of given plant gene and determining its sequence elements using PlantCare

**Suggested Readings:**

1. The Biochemistry of the Nucleic Acids; Adams RLP, Knowler JT and Leader DP,Chapman and Hall Publication.
2. Genetics; Peter JR and Benjamin S, Cummings Publication.
3. Recombinant DNA; Watson JD, Tooze T, Kurtz DT, Scientific American Books.
4. Principles of Gene Manipulation; Old RW and Primose SB. Blackwell Scientific
5. Publication.
6. Molecular Biotechnology; Glick and Pasternack, ASM press.

**Semester -7**

**CC-BIOTECHNOLOGY-16**

**Paper: IN-BTY- 703**

**BIOPROCESS AND FERMENTATION TECHNOLOGY**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes:** After successful completion students will be able to

* 1. Describe the techniques of isolation, screening and improvement of industrially important microbial strains.
	2. Describe the designing of a bioreactor with different modifications
	3. Give an insight of upstream and downstream processing
	4. Explore applications and achievements of fermentation technology in the field of medicine.

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**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**UNIT-I**

**Introduction** to bioprocess technology.Range of bioprocess technology and its chronological development.Basic principle components of fermentation technology.Types of microbial culture, Isolation and screening of microbes of industrial importance, Strain improvement: mutation and genetic manipulations

Culture preservation techniques and its growth kinetics– Primary and Secondary metabolites, Feedback inhibition & repression, Batch, Fedbatch and Continuous culture.

**Design of bioprocess vessels**- Significance of Impeller, Baffles, Sparger; Types of culture/production vessels- Airlift; Cyclone Column; Packed Tower and their application in production processes.Principles of upstream processing – Media preparation, Inocula development and sterilization.

**UNIT-II**

**Introduction** to oxygen requirement in bioprocess Energetics of microbial growth in fermenters: Reaction rates, heat and mass transfer, transport phenomenon in reactors, macrscopic balances of energy and energy flow etc

**Introduction** to Upstream and downstream processing of industrial fermentations, Cell disruptions, Flocculation, Filterations, Ultrafilteration, ultracentrifugation, gel filtration, chromatographic methods, two phase aqueous separations. Cells andenzyme immobilizations Fermentation of :Antibiotics (Penicillin, Streptomycin), Organic acids (Citric acid, Lactic acid), Enzymes (Penicillin G Acylase, Streptokinase), ethanol, Recombinant Proteins (Insulin).Hygiene and safety in fermentation laboratory

**SUGGESTED READINGS:**

1. Casida LE. (1991). Industrial Microbiology.1st edition.Wiley Eastern Limited.
2. Crueger W and Crueger A. (2000). Biotechnology: A textbook of Industrial Microbiology. 2nd edition.Panima Publishing Co. New Delhi.
3. Patel AH. (1996). Industrial Microbiology.1st edition, Macmillan India Limited.
4. Stanbury PF, Whitaker A and Hall SJ.(2006). Principles of Fermentation Technology.2nd edition, Elsevier Science Ltd.
5. Biotransformations and Bioprocesses (Biotechnology and Bioprocessing Series); Doble M, Kruthiventi AK and Gaikar VG, CRC Publisher.
6. Bioprocess Engineering Basic Concepts; Prentice Hall Publisher
7. Principles of Fermentation Technology; Stanbury PF, Whitaker, A Hall S.
8. Bioprocess Engineering: Basic Concepts; Shuler ML and Kargi F, Prentice Hall PTR Publisher.
9. Solid-State Fermentation Bioreactors: Fundamentals of Design and Operation; Mitchell DA, Krieger N, and Berovic M, Springer Publisher

**Semester -7**

**CC-BIOTECHNOLOGY-16**

**Paper: IN-BTY- 704**

**BIOPROCESS AND FERMENTATION TECHNOLOGY-PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes:** After successful completion students will be able to

* 1. Isolate economically important microbes from environment and perform biomass and metabolite production in microbial cultures.
	2. Demonstrate analysis of produced metabolites

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. Production of red wine.
2. Estimation of acids formed during wine production.
3. Estimation of alcohol produced in wine by dichromate titration method.
4. Production and analysis of amylase.
5. Production and analysis of lactic acid.
6. Isolation of industrially important microorganism from natural resource.

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**SUGGESTED READINGS:**

1. Biotransformations and Bioprocesses (Biotechnology and Bioprocessing Series); Doble M, Kruthiventi AK and Gaikar VG, CRC Publisher.
2. Bioprocess Engineering Basic Concepts; Prentice Hall Publisher
3. Principles of Fermentation Technology; Stanbury PF, Whitaker, A Hall S.
4. Bioprocess Engineering: Basic Concepts; Shuler ML and Kargi F, Prentice Hall PTR Publisher.
5. Solid-State Fermentation Bioreactors: Fundamentals of Design and Operation; Mitchell
6. DA, Krieger N, and Berovic M, Springer Publisher.

**Semester -7**

**CC-BIOTECHNOLOGY-17**

**Paper: IN-BTY- 705**

**BIOSTATISTICS**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

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**Learning Outcomes:** After successful completion students will be able to

* 1. Comprehend the fundamental concepts related to descriptive and inferential biostatistics.
	2. Develop skills in data tabulation, its treatment, analysis, interpretation and graphical representation of data.
	3. Analyze the implications of inferential statistics in biology.
	4. Develop their competence in hypothesis testing and interpretation.

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

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**UNIT-I**

**Biostatistics**: History of the field, objectives and connection with population genetics, levels of measurements, types of variables, precision vs accuracy

**Data Summarization and Visualization**: Types of variables, frequency tabulations (EFD, ERFD, ECD), various types of charts, error bars, scatterplots, Concepts of moments, Skewness and kurtosis, Intuitive definition of random variables, probability mass function and probability density function, expectation and variance .Standard distribution; binomial, Poisson and normal distribution with their important properties and significance.

**UNIT-II**

**Descriptive Statistics**  : measures of central tendency (mean, mode, median) and their dispersion, geometric mean - merits & demerits. Measures of dispersion - range, standard deviation, mean deviation, quartile deviation - merits and demerits; Co- efficient of variations.

**Correlation, Regression and Statistical inference**: Fitting of main distributions and testing of goodness –of – the –fit with special reference to χ2- test, t –test, Z-test. Fitting of trends; linear and quadratic with least square method.Lines of regression, coefficient of correlation, coefficient of variation and their significance.Analysis of variance; one way and two way classification. Learn applications of statistics in the field of biology

**Suggested Readings:**

1. Biostatistics; Arora PN, Malhotra PK, Himalaya Publishing House.
2. Introduction to Biostatistics; Sokal S &Rohit S, Toppan Publication.
3. Le CT (2003) introductory biostatistics. 1st edition, John Wiley, USA
4. Glaser AN (2001) High YieldTM Biostatistics. Lippincott Williams and Wilkins, USA
5. Edmondson A and Druce D (1996) Advanced Biology Statistics, Oxford University Press.
6. Danial W (2004) Biostatistics: A foundation for Analysis in Health Sciences, John Wiley and Sons Inc

**Semester- 7**

**CC-BIOTECHNOLOGY-17**

**Paper: IN-BTY- 706**

**BIOSTATISTICS - PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes:** After successful completion students will be able to

* 1. Solve the problems based on graphical Representation and measures of Central Tendency & Dispersion.
	2. Solve the problems based on Distributions Binomial Poisson Normal, t, f, z and Chi-square

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; computers, internet facility; softwares

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. For the given ungrouped data, construct the exclusive and inclusive type frequency distribution.
2. Draw the multiple and subdivided bar diagram for the given data.
3. To find the various measures of central tendency for the given frequency distribution.
4. To find the quartiles, deciles and percentiles for the given frequency distribution.
5. Calculate the mean deviation, variance, standard deviation and coefficient of variation for the given data.
6. Fit a binomial distribution for the given data.
7. Fit a Poisson distribution for the given data.
8. Fit a normal distribution for the given data.
9. To test a given null hypothesis using Chi-square test of goodness of fit.
10. To test the single mean using t-test.
11. To test if there is any significance difference between means from two different samples.
12. To test the single proportion using t-test.
13. To fit a straight line using principle of least squares.
14. To fit a parabola for the given bivariate data using principle of least squares.

**Suggested Readings:**

1. Biostatistics; Arora PN, Malhotra PK, Himalaya Publishing House.
2. Introduction to Biostatistics; Sokal S &Rohit S, Toppan Publication.
3. Le CT (2003) Introductory biostatistics. 1st edition, John Wiley, USA
4. Glaser AN (2001) High YieldTM Biostatistics. Lippincott Williams and Wilkins, USA
5. Edmondson A and Druce D (1996) Advanced Biology Statistics, Oxford University Press.
6. Danial W (2004) Biostatistics: A foundation for Analysis in Health Sciences, John Wiley and Sons Inc

**Semester – VII**

**DSE5-BIOTECHNOLOGY**

**Paper: IN-BTY-707**

**NANOTECHNOLOGY**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes**: After the successful completion of the course the student will be able to

* 1. Describethe basic fundamentals of nanobiotechnology with detail understanding of different nanomaterials, their types and properties.
	2. Acquire the knowledge on different nano-fabarication methods and will be skilled in various visualization and characterization techniques requires for nanomaterials.
	3. Understand about the principles of interaction of biomolecules to the surfaces of different nanomaterials and their relevance in the biomedical sciences.
	4. Explain use of nanoparticals in medical care and will understand the possible impact of nanotechnology on society, industry and environment.

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

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**Unit-I**

**Introduction to Bio-Nanotechnology**: The world of small dimensions (Nanoworld), history, scientific revolutions and current practice; dimensionality and size dependent phenomena, properties at nanoscale, Nanomaterials synthesis techniques.

**Nanoparticle**s: classification & types: classification based on dimensionality, (synthesis, properties and applications of Fullerens, Carbon nanotube, Metal nanoparticles, Quantum dots, Dendrimers, Multilayer Thin Film: Polyelectrolyte multilayers, coated colloids, smart capsules Biological nanomaterials, bioactive nanoparticles (respiratory surfactants, magnetic nanoparticles)

**Visualization & Characterization techniques for nanoparticles**: Electron microscopy: FESEM, HRTEM, Scanning probe microscopy: AFM, STM, Diffraction techniques (XRD), UV-Vis & FTIR, light scattering

**Unit-II**

**Biomolecules and nanotechnology**: Biomolecular Structure and Stability, Protein Folding, Self assembly, self-organization, molecular recognition, Flexibility, Information-Driven Nano-assembly, Energetics, Chemical Transformation, Biomolecular Motors, Traffic Across Membranes, Machine-Phase Bio-nanotechnology

**Nanobiotechnology applications**: Nanoparticles for drug delivery (including biopolymeric), Tissue engineering, Nanoengineered biosensors, Nanoengineered biosensors, Fiber Optic, Nano-sensors in medical care, Semiconductor and Metal Nanoparticles, bio-imaging, cancer nanotechnology,

**Nanobiotechnology Challenges**: Nanotoxicology challenges, Impact of nanotechnology on society and industry

**Suggested Reading**

* Multilayer Thin Films; Decher G, Schlenoff JB, Wiley-VCH Verlag GmbH & Co.
* Bionanotechnology : Lessons from Nature; Goodsell DS, Wiley-Liss.
* Nanotechnology - A Gentle Introduction to the Next Big Idea; Ratner and Ratner, Prentice Hall PTR.
* Niemeyer and Mirkin ed. Nanobiotechnology: concepts, applications & perspectives,
* David S Goodsell, “Bionanotechnology”, John Wiley & Sons, 2004
* Jain, KK. Nanobiotechnology in molecular diagnostics: current techniques and applications
* T. Pradeep, “A Textbook of Nanoscience and Nanotechnology”, Tata McGraw Hill Education Pvt. Ltd., 2012 2.

**Semester – VII**

**DSE5-BIOTECHNOLOGY**

**Paper: IN-BTY-708**

**NANOTECHNOLOGY-PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes:** After successful completion students will be able to

708.1 Synthesize nanoparticals by diverse methods

708.2 characterize nanoparticals byUV-Vis, FTIR, XRD and prepare samples for electron microscopy

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; computers, internet facility; softwares

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

Practicals:

1. Synthesis of nanoparticles by using biological process including E.coli – (2-3 methods).
2. Synthesis of Al2O3 nanoparticles using sol-gel/chemical method.
3. Detection of nanoparticles in colloidal solutions using UV-Vis absorption Technique.
4. Characterize nanoparticles by UV-Vis & FTIR, XRD methods
5. Biological sample preparation for SEM/TEM
6. Demonstrate about Nano-sensors in medical care and analyze blood/urine samples by using sensor-based tools
7. Synthesis of semiconductor (ZnS, CdS etc.) nanoparticles by chemical method.

**Semester – VII**

**DSE5-BIOTECHNOLOGY**

**Paper: IN-BTY-709**

**MEDICAL MICROBIOLOGY**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes**: After the successful completion of the course the student will be able to

* 1. Describebasic principles of medical microbiology, infectious diseases and mechanisms of disease transmission and the role of microflora of the human body.
	2. Understand the morphology, pathogenesis, symptoms, laboratory diagnosis, preventive measures and chemotherapy of gram positive and gram negative bacteria.
	3. Explain about viral pandemic, epidemic and endemic diseases.
	4. Understand the importance of pathogenic microorganisms (fungal and protozoan) in human disease with respect to systemic, subcutaneous, gastrointestinal tract infections and infections to immunocompromized host.

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**UNIT I**

Introduction: Normal microflora of human body, nosocomial infections, carriers, septic shock, septicemia, pathogenicity, virulence factors, toxins, biosafety levels.

Morphology, pathogenesis, symptoms, laboratory diagnosis, preventive measures and chemotherapy of gram positive bacteria: S.aureus, S.pyogenes, B.anthracis, C.perferinges, C.tetani, C.botulinum, C.diphtheriae M.tuberculosis, M. leprae.

Morphology, pathogeneis, symptoms, laboratory diagnosis, preventive measures and chemotherapy caused by gram negative bacteria: E.coli, N. gonorrhoea, N. meningitidis, P. aeruginosa, S. typhi, S. dysenteriae, Y. pestis, B. abortus, H. influenzae, V. cholerae, M. pneumoniae, T. pallidum M. pneumoniae, Rickettsiaceae, Chlamydiae.

**UNIT II**

Diseases caused by viruses- Picornavirus, Orthomyxoviruses, Paramyxoviruses, Rhabdoviruses, Reoviruses, Pox virus, Herpes virus, Papova virus, Retro viruses (including HIV/AIDS) and Hepatitis viruses, SARS (Severe Acute Respiratory Syndrome), MERS (Middle East respiratory syndrome)

Fungal and Protozoan infections. Dermatophytoses (Trichophyton, Microsporun and Epidermophyton) Subcutaneous infection (Sporothrix, Cryptococcus), systemic infection (Histoplasma, Coccidoides) and opportunistic fungal infections (Candidiasis, Aspergillosis), Gastrointestinal infections (Amoebiasis, Giardiasis),

Blood-borne infections (Leishmaniasis, Malaria)

**SUGGESTED READINGS**

* Brooks GF, Carroll KC, Butel JS and Morse SA. (2007). Jawetz, Melnick and Adelberg’s Medical Microbiology. 24th edition. McGraw Hill Publication.
* Goering R, Dockrell H, Zuckerman M and Wakelin D. (2007). Mims’ Medical Microbiology. 4th edition. Elsevier.
* Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein’s Microbiology. 7th edition. McGraw Hill Higher Education.

**Semester – VII**

**DSE5-BIOTECHNOLOGY**

**Paper: IN-BTY-710**

**MEDICAL MICROBIOLOGY-PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes:** After successful completion students will be able to

710.1 Isolate and characterize pathogens from clinical samples

710.2 determine antibacterial activity by different methods

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; computers, internet facility; softwares

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. Isolation of following pathogens from clinical samples (wherever possible) and identification of the same by morphological, cultural and biochemical characteristics: IMViC, TSI, nitrate reduction, urease production and catalase tests
	1. Pseudomonas aeruginosa
	2. Staphylococcus aureus
	3. Candida albicans
2. Study of microbial flora of skin/sliva/buccal cavity/nose by swab method
3. Determination of sensitivity of common pathogens to antibiotics by paper disc method.
4. Perform antibacterial sensitivity by Kirby-Bauer method
5. Serological tests:
	1. Widal test -Quantitative
	2. Rapid Diagnostic Test for Malaria

**Books recommended for Practical :**

1. Medical Lab Technology - Ramnikand Sood, Jaypee brothers(Medical pub, New Delhi)
2. Practical Biochemistry -Plummer
3. APHA(American Public Health Association)Handbook
4. Soil, Plant and Water Analysis- P.C. Jaiswal
5. Biochemical methods-S. Sadasivam, A. Manickam
6. Practical Biochemistry-J. Jayraman 7. Practical Microbiology – R.C. Dubey , D. K. Maheshwari , S. Chand & Co. Ltd.

**Semester – 8**

**CC-BIOTECHNOLOGY-18**

**Paper: IN-BTY- 801**

**ADVANCED RECOMBINANT DNA TECHNOLOGY**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

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**Learning Outcomes**: On successful completion of the course the student will be able to:-

* 1. Learn in-depth understanding about gene library and their types along with diverse procedures required for selection of rDNA clones and their expression products including In-situ hybridization and Protein-protein interactions
	2. Understand the concept of mutagenesis, types and their impact on gene modification
	3. Learn about different approaches to be used for studying gene expression, its regulation and manipulation of recombinant gene expression in Prokaryotes
	4. Describe about heterologous protein production in diverse eukaryotic cell systems and will elucidate wide applications of rDNA technology including in medical care and food industry

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**UNIT-I**

**Genomic and cDNA library**: Gene library, types and Applications, Making genomic and cDNA libraries in plasmids and phages. PCR product cloning (TA cloning), cDNA synthesis strategies – Linkers – Adapters – Homopolymer tailing; Properties of cDNA, mRNA enrichment

**Selection of rDNA clones and their expression products**: Direct and indirect methods. Drug resistance, gene inactivation, DNA hybridization, Colony and Plaque hybridization; Abundancy probing, Heterologus probing, In-situ hybridization (Southern, Northern and Dot blots and immunological techniques Western blotting), Subtractive hybridization; Protein-Protein interactions **-** Phage display, Yeast two hybrid system, Yeast three hybrid system.

**Site Directed Mutagenesis:** Oligonucleotide directed mutagenesis, PCR amplified oligonucleotide directed mutagenesis, Random mutagenesis with degenerate oligonucleotide primers / nucleotide analogs. Deletion mutagenesis, Applications

**UNIT-II**

**Gene expression and Regulation studies:** Primer extension, S1 mapping, RNase protection assay, Gel retardation assay, Deletion analysis, Reporter genes, DNA foot printing, Modification interference assays, HRT, HART

**Manipulation of recombinant gene expression in Prokaryotes:** Problems with production of recombinant proteins in *E coli*, Optimizing expression of foreign genes in *E.coli*- Strong and regulatory promoters, Codon usage, Fusion proteins, Increasing protein stability and secretion, Translation expression vectors, Protease deficient host strains.

**Heterologous protein production in Eukaryotes:** *Saccharomyces cerevisiae*and *Pistia pastoris*expression systems, Baculovirus Insect cell expression systems, Mammalian cell expression system, CRE LOX system and CRISPR/Cas9

**Applications of rDNA technology**: Diagnostics; Pathogensis; Genetic diversity; Therapeutic proteins-Vaccines. Molecular probes (Production, labelling and uses)

**Suggested Readings:**

* + - 1. Gene cloning and DNA analysis – An Introduction (2006) 5th edition, T.ABrown, Blackwell publisher.
		1. Essential genes (2006), BenzaminLewin, Pearson education international.
		2. Genome-3 (2007) T.A Brown. Garland science, Taylor & Francis, NewYork.
		3. Principles of gene manipulation and Genomics (2006) 7th edition, S.B Primoseand R.M Twyman, Blackwell publishing.

**Semester-8**

**CC-BIOTECHNOLOGY-18**

**Paper: IN-BTY- 802**

**ADVANCED RECOMBINANT DNA TECHNOLOGY - PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes**: On successful completion of the course the student will be able to

* 1. Exhibit the skill to study any damage and mutations in the isolated DNA
	2. Demonstrate analysis of Cre-Lox and CRISPR/Cas9 systems used for production of recombinant gene products

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals**

1. To study *in vitro* DNA damage and analysis by agarose gel electrophoresis by using either purified DNA or plasmid.
2. Designing primers for PCR using online tools.
3. To study mutagenesis concept by using cancer-causing agents
4. Perform any method to be used for the selection of recombinant DNA clone
5. Gene expression in *E. coli* and analysis of gene product
6. Demonstration about Mammalian cell expression system with uses of CRE-LOX system
7. Demonstration about Mammalian cell expression system with uses of CRISPR/Cas9 system

**Suggested Readings:**

* + - 1. Biotechnology-Applying the genetic Revolution (2009), Clark and Pazdernik, Academic Press
			2. Molecular Cloning : A Laboratory Manual (2000), J. sambrook, E.F. Fritsch and T.Maniatis, Cold Spring Harbor Laboratory Press, New York
			3. DNA Cloning : A Practical Approach (1995) , D.M. Glover and B.D. Hames, IRL Press, Oxford,
			4. Genetic Engineering. An Introduction to gene analysis and exploitation in eukaryotes (1998), S.M. Kingsman and A.J. Kingsman, Blackwell Scientific Publications, Oxford.

**Semester – 8**

**CC-BIOTECHNOLOGY-19**

**Paper: IN-BTY- 803**

**ANIMAL CELL CULTURE**

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**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

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**Learning Outcomes**: On successful completion of the course the student will be able to:-

* 1. Describe the biology of cultured cells and basic requirements of animal cell culture
	2. Elaborate the diverse media require for animal cell culture with their merits & demerits and will extend the diverse applications of animal cell culture
	3. Illustrate about the primary cell culture, sub-culture along with various parameters of cell line characterizations
	4. Understand the concept of cell cloning, techniques to scale up production of cell, organ culture and will explain diverse types of stem cells including satellite cells, iPS and their impact in future therapy against incurable diseases

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**Unit-I**

**Biology of the Cultured Animal Cells, Tissue & Organ:** Historical, Advantages and limitations - medical/pharmaceutical products of animal cell culture and their applications. Risks in a tissue culture laboratory and safety - biohazards.

**Facilities for animal cell culture:** Infrastructure, Equipments including Biosafety Cabinets and Laminar Air Flow, Culture vessels – types (treated, Non-treated surfaces), the substrate, Nitrogen Container, CO2 incubator, Filters-sizes, types (for aqueous solution, for DMSO soluble solution). Biology and characterization of cultured cells-cell adhesion, proliferation, differentiation, morphology of cells and identification. Evolution of cell lines, development of continuous cell lines, dedifferentiation

**Culture Media:** Balanced salt solutions, Complete media including proliferation, differentiation, Freezing and wash media. Brief discussion on the chemical, physical and metabolic functions of different constituents of culture medium. Role of CO2, Serum and Supplements. Serum free media and their application: advantages and disadvantages of serum and serum free media, replacement of serum and development of serum free media.

**Applications of Animal Cell Culture:** Production of high value therapeutics (enzymes, hormones, monoclonal antibody, cytokines etc), virology, cancer research, gene therapy, drug development and cytotoxicity, animal cloning, genetic counseling, cryopreservation of cells.

**Unit-II**

**Primary Cell Cultures and Sub-cultures:** types of primary cell culture, isolation of the tissue and preparation of primary cell culture, characteristics of limited life-span cultures, Techniques (mechanical disaggregation, enzymatic treatment, separation of viable and non-viable cells); Subculture and propagation, Criteria for subculture, Subculture of monolayer cells, growth cycle and split ratio, propagation and subculture in suspension ;

**Cell Lines and Characterization:** Establishment and properties of continuous cell lines; Need for characterization, authentication (lineage or tissue markers), cell morphology, chromosome content, DNA content, RNA and protein expression, enzyme activity, antigen markers.

**Cell Cloning:** Development of cloning techniques, dilution and suspension cloning, scaling up in suspension and monolayer, large scale production of cells using bioreactors, special requirement of cells growing at very low densities, uses of cloning; Organ culture - whole embryo culture

**Stem Cell Culture**

Embryonic and adult stem cells and their applications. Satellite Cells. Totipotent, Pluripotent and Multipotent stem cells. Induced Pluripotent Stem Cells (iPS) – Concept, Discovery, its impact on research in stem cell biology and in future therapy

**Suggested Readings:**

1. Animal Cell Culture - Practical Approach, Ed. John R.W. Masters, OXFORD.
2. Animal Cell Culture Methods In: Methods in Cell Biology, Vol. 57, Ed. Jenni P Mather and David Barnes, Academic Press.
3. Animal Cell Culture Techniques. Ed. Martin Clynes, springer.
4. Biotechnology, Vol. 7b 1993 Rehm. H.J. and Reed, G.(eds) VCH Publications.
5. Cell Culture Lab Fax. Eds. M Butler & M. Dawson, Bios Scientific Publications Ltd. Oxford.
6. Cell Growth and Division: a Practical Approach. Ed. R. Basega, IRL Press.
7. Culture of Animal Cells, (3rdedition), R. Ian Freshney. Wiley-Liss.

**Semester – 8**

**CC-BIOTECHNOLOGY-19**

**Paper: IN-BTY- 804**

**ANIMAL CELL CULTURE-PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes**: On successful completion of the course the student will be able to learn:

* 1. Prepare and sterilize media used in animal cell culture
	2. Culture, check viability, iPS and animal cell culture process

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. Preparation and sterilization of different types of cell culture media i.e. RPMI 1640, Balanced Salt solutions, MS basal media, NAM.
2. To isolate lymphocytes from whole blood by gradient centrifugation
3. To culture lymphocytes using RPMI1640 media.
4. To check cell viability by cell counting
5. To check cell viability by MTT staining
6. Demonstrate the culture of iPS
7. Demonstrate the complete process of animal cell culture including freezing, thawing, proliferations etc by taking suitable example of cell line

**Suggested Readings:**

1. Animal Cell Culture - Practical Approach, Ed. John R.W. Masters, OXFORD.
2. Animal Cell Culture Methods In: Methods in Cell Biology, Vol. 57, Ed. Jenni P Mather and David Barnes, Academic Press.
3. Animal Cell Culture Techniques. Ed. Martin Clynes, springer.

**Semester-8**

**CC-BIOTECHNOLOGY-20**

**Paper: IN-BTY- 805**

**BIOENTERPRENEURSHIP DEVELOPMENT**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes**: On successful completion of the course the student will be able to:

* 1. Exhibit the knowledge of structure, management and role of innovations in an organization
	2. Discuss the government schemes for commercialization of biotechnology
	3. Describe various elements of operational research and management
	4. Compare and analyse the characteristics of biotech enterprises, various parameters of quality control and government regulations.

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**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**UNIT-I**

Creativity & Entrepreneurial personality and Entrepreneurship in Biotechnology

Organizational structure & Management; Capital Management; Product innovation and management; Government schemes for commercialization of technology (Eg. Biotech Consortium); Basics of production management:

Methods of manufacturing-Project/Jobbing, Batch Production, Flow/Continuous production, process production-Characteristics of each method. Plant location-Importance-Factors affecting location-factory Building-Plant layout-Installation of Facilities.

**UNIT-II**

Operational Research: Linear Programming, PERT and CPM;

Production Planning & Control-Scheduling-Gantt Charts-Documentation-Production Work Order. Kaizen (Continuous improvement in product & management);

Biotech enterprises: Small, Medium & Large; Quality control in Biotech industries; Govt. regulations for biotech products; Public policy, regulatory and ethical challenges facing the biotechnology

Entrepreneurship; Business development for medical products

**Suggested Reading**

1. Holt DH. Entrepreneurship: New Venture Creation.
2. Kaplan JM Patterns of Entrepreneurship.
3. Gupta CB, Khanka SS. Entrepreneurship and Small Business Management, Sultan Chand &Sons.Innovation and Entrepreneurship in Biotechnology: Concepts, Theories &Cases;
4. Hyne D and KapelerisJ.Entrepreneurship in Biotechnology: Managing for growth from start-up; Martin Gross Mann.
5. Best Practices in Biotechnology Education; Friedman Y, Logos Press.

**Semester-8**

**CC-BIOTECHNOLOGY-20**

**Paper: IN-BTY- 806**

**BIOENTERPRENEURSHIP DEVELOPMENT-PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes**: On successful completion of the course the student will be able to:

* 1. Analyse his personality and ability as an entrepreneur
	2. Plan and analyse the requirement and status of Biotech industry

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; computers, Internet facility

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals**

1. To analyze your entrepreneurial personality and creativity
2. To analyze your entrepreneurial potential by performing online Bill Wager’s self assessment test.
3. To analyze your personality type by performing online Jung & Myer Brigg’s assessment test.
4. To analyze personality type by performing online DISC self assessment test.
5. To make a business plan.
6. To study Biotech Enterprises

**Suggested Reading:**

1. Holt DH. Entrepreneurship: New Venture Creation.
2. Kaplan JM Patterns of Entrepreneurship.
3. Gupta CB, Khanka SS. Entrepreneurship and Small Business Management, Sultan Chand & Sons. Innovation and Entrepreneurship in Biotechnology: Concepts, Theories & Cases;
4. Hyne D and KapelerisJ.Entrepreneurship in Biotechnology: Managing for growth from start-up; Martin Gross Mann.
5. Best Practices in Biotechnology Education; Friedman Y, Logos Press.

Open Elective, IN-BTY-807 will be the same as Open Elective-Biotechnology and Human Welfare-I, approved by PGBOS, Department of Biotechnology, Kurukshetra University Kurukshetra

**Semester-9**

**CC-BIOTECHNOLOGY-21**

**Paper: IN-BTY- 901**

**BIOINSTRUMENTATION**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

**Learning Outcomes**: On successful completion of the course the student will be able to:

* 1. Describe the principles and types of various techniques like spectroscopy, centrifugation and chromatography
	2. Elaborate the applications of advanced techniques in isolation and purification of biomolecules
	3. Describe the principles and applications of various techniques of multiplication and characterization of nucleic acids
	4. Give an insight of applications of immunotechniques and biosensors

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**UNIT-I**

**Spectroscopy:** Raman, Fluorescence and NMR spectroscopy; ORD & CD; Mass spectrometry, MALDI-TOF, LC-MS; X-ray diffraction; Atomic absorption spectroscopy; Applications of these spectroscopic techniques in the study of Biomolecules

**Centrifugation:** Basic principles of sedimentation; types of centrifuge (Bench top, high speed& ultracentrifuges); types of rotor; Preparative & analytical centrifugation. Separation methods-Differential centrifugation, Density gradient centrifugation; Subcellular fractionation- Disruption of cells, isolation of subcellular organelles from liver & plant cells and marker enzymes

**Advanced purification techniques**: FPLC, HPLC

**UNIT-II**

**Nucleic acid based techniques** – Northern, Southern, Sequencing of proteins and nucleic acids, PCR, RT-PCR, QRT-PCR, DNA microarray, DNA fingerprinting (RFLP, RAPD, AFLP, SSR)

**Immunotechniques**- Flow cytometry, Immuno-cytochemistry, immune-fluorescence and Western & Dot blots, Florescence activated cell sorter (FACS) technique, Cytotoxicity assay

**Biosensors -** Principle and application

**Suggested Readings:**

1. Bioinstrumentation, Student; John GW, John Wiley & Sons Ltd.
2. Practical Biochemistry Principles and Techniques; Wilson K and Walker J, Cambridge University Press.
3. Essentials of Molecular Biology; Malacinski GM, Freifelder D, Jones & Bartlett Publishers.
4. Proteins-Structure and Molecular Properties; Creighton TE, Freeman and Company.
5. Genes IX; Benjamin L, Jones and Bartlett Publishers.

**Semester-9**

**CC-BIOTECHNOLOGY-21**

**Paper: IN-BTY- 902**

**BIOINSTRUMENTATION-PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes:** Students who successfully complete this course will be able to

* 1. Isolate subcellular organelles from animal and plant tissues.
	2. Perform electrophoresis, zymography and analyse the results

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practicals:**

1. To prepare absorption spectrum of plant pigments by UV- Vis spectroscopy
2. Isolation of subcellular organells from animal tissue and identification by marker enzymes
3. Isolation of subcellular organells from plant tissue and identification by marker enzyme.
4. Determination of cytotoxic concentration (IC50)
5. Perform SDS PAGE, Zymography and demonstrate about Western blotting
6. Demonstrate about the FACS
7. Demonstrate about chromatography specifically HPLC

**REFERENCES:**

* Bioinstrumentation, Student; John GW, John Wiley & Sons Ltd.
* Practical Biochemistry Principles and Techniques; Wilson K and Walker J,

Cambridge University Press.

* Essentials of Molecular Biology; Malacinski GM, Freifelder D, Jones & Bartlett

Publishers.

* Proteins-Structure and Molecular Properties; Creighton TE, Freeman and Company.
* Genes IX; Benjamin L, Jones and Bartlett Publishers.

**Semester – IX**

**CC-BIOTECHNOLOGY-22**

**Paper: IN-BTY- 903**

**RESEARCH METHODOLOGY**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

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**Learning Outcomes**: On successful completion of the course the student will be able to:

* 1. Elaborate the concept of research and different types of research in the context of biology
	2. Develop laboratory experiment related skills.
	3. Develop competence on data collection and process of scientific documentation
	4. Analyze the ethical aspects of research and evaluate the different methods of scientific writing, reporting and focuses on plagiarism

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**UNIT-I**

**Basic Concepts of Research**: Meaning –Purpose, Types and significance of research in basic/applied sciences. Steps in Research: Identification, selection and formulation of research problem- Research questions-Research design- Formulation of hypothesis- Literature collection, Review of literature.

**Journals:** standard of research journals, impact factor - citation index. Information retrieval - access to archives and databases, search engines - google, pubmed - national informatics center network services. Online data base library.Internet as a medium of interaction between scientists; Effective email strategy using the right tone and conciseness.

**Measures of dispersion**: Sampling theory-Types of sampling-Steps in sampling- Sampling and Non-sampling error-Sample size – Advantages and limitations of sampling. Scaling method – mean, standard deviation, standard error - coefficient of variation; Comparisons of means- Students t-test and ANOVA

**UNIT-II**

**Data for Research**: Primary data-Meaning-Collection methods-Observation–Interview- Questionnaire-Schedule-Pretest-Pilot study –Experimental and case studies- Secondary data- Meaning – Relevance, limitations and cautions. Processing Data: Checking- Editing-Coding- transcriptions and Tabulation-Data analysis- Meaning and methods- Quantitative and Qualitative analysis

**Structuring the Report**: Chapter format- Pagination- Identification- Using quotations- Presenting footnotes – abbreviations- Presentation of tables and figures- Referencing- Documentation-Use and format of appendices- Indexing

**Preparation of Research report & Proposal**- Thesis - dissertation -Manuscript/research article –monograph/review, Research Proposal; Check Plagiarism; Oral and poster presentation of research papers in conferences/symposia/workshop.

**Suggested Readings:**

1. Dawson, C. (2002). Practical research methods.UBS Publishers, New Delhi.
2. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, Hong Kong.
3. MS office; Sexena S, Vikas Publishing House.
4. Statistical methods; Snedecor GW and Cohran WG, Oxford and IBH publishing CO Pvt. Ltd.
5. Biometry; Sokal RR and Rohlf FJ, Freeman WH publishing House.
6. Biostatistical analysis; Zar JH, Prentice Hall Publishing House.

**Semester – IX**

**CC-BIOTECHNOLOGY-22**

**Paper: IN-BTY- 904**

**RESEARCH METHODOLOGY - PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes**: On successful completion of the course the student will be able to

* 1. Design, plan and write up the research proposals
	2. Demonstrate skill in critically analyzing the observations to draw inference

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; computers, internet facility

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**Practical**

1. Demonstrate about methods involved (including survey/questionnaires/interviews/ case studies/observations etc) in writing a research paper/manuscript/article
2. Demonstrate about methods involved (including survey/questionnaires/interviews etc) in writing a review paper/manuscript/article
3. Formulate a statistic problem and answer with the help of Scaling method (SD/SEM) by taking suitable examples related to biotechnology
4. Formulate a statistic problem and answer with the help of Comparisons of means (T-test/Anova) by taking suitable examples related to biotechnology
5. Oral Presentation of a research paper
6. Poster presentation of a research paper
7. Demonstration about plagiarism using available softwares
8. Demonstrate about curation of relevant scientific literature/journals, impact factor and its purpose by using online tools/webpage including Google Scholar, PubMed, Science Direct etc at the time of preparation and submission of a new manuscript

**Suggested Readings:**

1. Dawson, C. (2002). Practical research methods.UBS Publishers, New Delhi.
2. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, Hong Kong.
3. MS office; Sexena S, Vikas Publishing House.
4. Statistical methods; Snedecor GW and Cohran WG, Oxford and IBH publishing CO Pvt. Ltd.
5. Biometry; Sokal RR and Rohlf FJ, Freeman WH publishing House.
6. Biostatistical analysis; Zar JH, Prentice Hall Publishing House.

**Semester -9**

**CC-BIOTECHNOLOGY-23**

**Paper: IN-BTY- 905**

**ENVIORNMENTAL BIOTECHNOLOGY**

**Credits: 4**

**Total Marks: 100**

**External Marks: 80**

**Internal Assessment: 20**

**Examination Time: 3 h**

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**Learning Outcomes**: On successful completion of the course the student will be able to

* 1. Describe various dimensions of ecology, biodiversity and their importance.
	2. Analyse the causes of air pollution and their control mechanisms
	3. Analyse the causes of water pollution and their control mechanisms using biotechnological processes
	4. Give an insight of application of biosources as the solution to various environmental concerns

**Approaches to teaching**

Lectures, Chalk and board teaching, power point Presentations, models, Group Discussion

**Requirements**

Regular attendance and active participation during the course; Books and reference material; assignments and presentations etc

**Evaluation**

The performance of the students will be evaluated against the expected learning course outcomes on the basis of class participation, regularity, house tests, quiz and assignments carrying 20 percent of the marks and the rest through Terminal Examination

**Mode of paper setting**

Seven questions will be set in all. Question No.1 comprising of objective/short answer type questions from the entire syllabus, will be compulsory. The remaining six questions will be set taking three questions from each unit. The candidates will be required to attempt Q.No.1 & four others selecting two questions from each unit. All questions carry equal marks.

**UNIT-I**

**Ecology & Biodiversity**

Introductory concepts, The biological world and Ecology: Ecological balance and consequences of change, Biological word and eco-systems; Biochemical Diversity in ecosystem development; Diversity indices; Cellular diversity and the classification of living system – Prokaryotic & Eukaryotic organisms, General physical properties and Tolerance to environmental conditions; Microbial Biodiversity – strategies – bio-prospecting and recovery.

**Air Pollution Control Methods and Equipment**

Primary and secondary air pollutants, standards, sampling, basic ideas of air pollution control equipments, Bag Filter, Electrostatic Precipitators, cyclone separators, Wet-scrubbers, Bioscrubbers, Electrostatic precipitators, High volume sampler, RSPM Sampler, Control of specific gaseous pollutants.

**UNIT-II**

**Wastewater Treatment by Biotechnological Processes**

Water pollution; sources and classification of pollutants, B.O.D, C.O.D, D.O, T.D.S, Oil and grease, Metals etc.Standards, sampling and method of analysis, Bacteriological measurements. Overview of treatment principles and theory of aeration, Municipal Sewer and Industrial Wastewater Treatment –Principles, operation and design aspects of: Activated Sludge process, Extended Aeration, Nitrification-denitrification, Trickling Filter, Mechanically aerated lagoons, Concepts of Waste stabilization ponds, Aquatic plant systems, Ranking of waste water treatment processes, common effluent treatment plant.

**Environmental Biotechnology: Specialized aspects**

Oil pollution – treatment with micro-organisms, Bioremediation- recovery of metals from waste water and sludge, xenobiotics, degradative capabilities of microorganisms with reference to toxicology, pesticides, herbicides, polyaromatic hydrocarbons, Anaerobic and aerobic composting, Vermiculture, Wetland Management, Membrane based waste water treatment processes – case studies.

**Suggested Readings:**

1. Fundamentals of Ecology; Odum EP.
2. Wastewater Engineering – Treatment, Disposal and Reuse; Metcalf & Eddy, Tata McGrawhill
3. Environmental Pollution Control Engineering, Rao CS, New Age International Publication.
4. Wastewater treatment for pollution control; Arceiwala SJ, TMH Publication.

**Semester -9**

**CC-BIOTECHNOLOGY-23**

**Paper: IN-BTY- 906**

**ENVIORNMENTAL BIOTECHNOLOGY-PRACTICALS**

**Credits: 2**

**Max. Marks: 50**

**External Marks: 40**

**Internal Assessment: 10**

**Time allowed: 3 h (one session)**

**Learning Outcomes**: On successful completion of the course the student will be able to:

* 1. Qualitatively analyse the soil samples and isolate microbes from soil
	2. Analyse the water samples for TDS, DO and COD

**Approaches to teaching**

Instructions, Chalk and board teaching, demonstrations, models, practical and practice

**Requirements**

Regular attendance and active participation during the course; reference material; laboratory equipments, glassware and chemicals

**Evaluation**

The performance of the students will be evaluated against expected learning course outcomes on the basis of class participation, regularity, performance in lab practicals, records and viva voce.

**PRACTICALS**

1. To study pH and moisture content of soil
2. To study carbonate and nitrate content of soil
3. Calculation of Total Dissolved Solids (TDS) of water sample
4. To determine dissolved oxygen (DO) of given water sample.
5. Determination of COD of given water sample.
6. DNA isolation from soil microbial community
7. Isolation of azotobacter species from soil

**Suggested Readings:**

1. Fundamentals of Ecology; Odum EP.
2. Wastewater Engineering – Treatment, Disposal and Reuse; Metcalf & Eddy, Tata McGrawhill
3. Environmental Pollution Control Engineering, Rao CS, New Age International Publication.
4. Wastewater treatment for pollution control; Arceiwala SJ, TMH Publication.

DSE-6, IN-BTY-907 & IN-BTY-908 will be the same as DSE-3, IN-BTY-605 & IN-BTY-606 in the present scheme

DSE-6, IN-BTY-909 & IN-BTY-910 will be the same as DSE-3, IN-BTY-607 & IN-BTY-608 in the present scheme

Open Elective, IN-BTY-911 will be the same as Open Elective-Biotechnology and Human Welfare-II, approved by PGBOS, Department of Biochemistry, KUK

**Semester -10**

**CC-BIOTECHNOLOGY-24**

**PROJECT**

**Credits: 20**

**Max. Marks: 500**

**Time allowed: 3 h (one session)**

**Programme Outcomes (POs) for UG Courses of Faculty of Life Sciences**

1. To develop skills in graduate students to be able to acquire theoretical and practical knowledge in fundamentals of biology in respective disciplines of plants, animals, microbes and environment.
2. To inculcate ability to critically evaluate problems and apply lateral thinking and analytical skills for professional development.
3. To create awareness on ethical issues, good laboratory practices and biosafety.
4. To develop ability in youth for understanding basic scientific learning and effective communication skills.
5. To prepare youth for career in teaching, industry, government organizations and self-reliant entrepreneurship.
6. To make students aware of natural resources and environment and its sustainable utilization.
7. To provide learning experience in students that instills deep interest in biological science for the benefit of society.

**Programme Specific Outcomes for UG Course in Biotechnology**

After the successful completion of the programme the student will be able to

**PSO1:** demonstrate the knowledge and understanding of biological sciences i.e., structure and function of biological molecules, biological mechanisms, such as the processes and control of bioenergetics and metabolism, as chemical reactions with engineering technologies to manipulate living organisms and biological systems to produce products that advance healthcare, medicine, agriculture, food, pharmaceuticals and environment control

**PSO2:** Critically think and correlate the biological knowledge of distribution, morphology and physiology of organisms (animals, plants and microorganisms) to techniques in aseptic procedures, isolation, identification, characterization and modifications to improve quality of life in person as well as community.

**PSO3:** Demonstrate an understanding of the principles of bio- techniques, and exhibit basic professional skills pertaining to biotechnology, carry out laboratory-orientated numerical calculations and analyse biological data (e.g. in enzyme kinetics, molecular structure analysis, microbiological techniques, immunological inferences)

**PSO4**: Scientific writing and authentic reporting, effective presentation skills and ability to work in a group with cooperation

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| **CORE COURSE - BIOTECHNOLOGY-1****BIOMOLECULES** |
| **CO#** | After the successful completion of the course the student will be able to |
| **101.1** | Classify, define and explain various properties of carbohydrates and correlate them to their functions |
| **101.2** | Classify, define, draw structures and explain functions of various types of lipids: Illustrate various parameters of characterization of lipids. |
| **101.3** | Classify, draw structures of standard amino acids, explain chemical and physical properties of amino acids; Describe different classes of proteins and explain different levels of structural organization in protein architecture. |
| **101.4** | Explain the characteristics and draw structures of various types of nucleic acids;Illustrate chemical and physical properties of nucleic acids.  |
| **102.1** | Prepare various types of solutions used in qualitative and quantitative biochemical estimations; verify and apply the basic principles of spectroscopy |
| **102.2** | Analyse the unknown samples qualitatively for the presence of various biomolecules |

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| CORE COURSE- **BIOMOLECULES** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **101.1** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **101.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **101.3** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **101.4** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **102.1** | 3 | 3 | 3 | 3 | 3 | 2 | 2 |  | 3 | 3 | 3 |
| **102.2** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 |
| **Average** | 3 | 3 | 2 | 3 | 3 | 2.83 | 2.66 | 2.5 | 3 | 2.33 | 3 |

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| **CORE COURSE - BIOTECHNOLOGY-2****GENERAL MICROBIOLOGY** |
| **CO#** | After the successful completion of the course the student will be able to |
| **103.1** | Illustrate the knowledge of history, scope, classification, various approaches of study and microbial diversity |
| **103.2** | Compare and characterize prokaryotic and eukaryotic cells based on morphology; different groups of microorganisms based on their structures. |
| **103.3** | Give an account of microbial growth, reproduction and metabolism |
| **103.4** | Identify the microorganisms in water and food along with methods to control them |
| **104.1** | Exhibit skills in preparation of media and staining |
| **104.2** | Isolate bacteria from different sources and determine their count and cell size  |

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| **CORE COURSE- GENERAL MICROBIOLOGY** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **103.1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **103.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **103.3** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 3 |
| **103.4** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **104.1** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 |
| **104.2** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 |
| Average | 3 | 3 | 2.5 | 3 | 3 | 2.83 | 2.66 | 3 | 3 | 2.5 | 3 |

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| **GENERIC ELECTIVE -ZOOLOGY -1****CELL BIOLOGY**  |
| **CO#** | After the successful completion of the course the student will be able to |
| **101.1** | Understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles |
| **101.2** | Understand how these cellular components are synthesized and degraded in cells  |
| **101.3** | Explain the structure and function of prokaryotic cell & its components |
| **101.4** | Describe the various models and solute transporter systems belonging to cell membrane and will explain cell cycle and apoptosis |
| **102.1** | Prepare slides of animal and plant cells and cell division  |
| **102.2** | Conduct the morphomatric analysis of chromosomes  |

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| **GENERIC ELECTIVE-CELL BIOLOGY**  |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **101.1** | 3 | 3 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 3 |
| **101.2** | 3 | 3 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 3 |
| **101.3** | 3 | 3 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 3 |
| **101.4** | 3 | 3 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 3 |
| **102.1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **102.2** | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 |
| **Average** | 3 | 3 | 2.33 | 3 | 3 | 2.16 | 2.33 | 2.33 | 2.16 | 2.33 | 3 |

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| **CORE COURSE - BIOTECHNOLOGY-3****ENZYMOLOGY** |
| **CO#** | After the successful completion of the course the student will be able to |
| **201.1** | Define various characteristics of enzymes, classify them and elaborate the role of cofactors in enzyme catalysis |
| **201.2** | Correlate the structure of enzymes to their functions, mechanism of enzyme catalysis and describe various approaches for purification of enzymes |
| **201.3** | Exhibit the knowledge of enzyme kinetics of unisubstrate reactions, various kinetics parameters (Km, Vmax etc.) and describe different types of enzyme inhibitions.  |
| **201.4** | Correlate different ways of enzyme regulation to cellular metabolism: discuss and analysethe industrial importance of enzymes and the techniques to use them. |
| **202.1** | Extract and quantitatively estimate the enzyme activity and protein content of the samples |
| **202.2** |  Exhibit skills in studying various characteristics of enzymes like pH optima, temperature optima, Km, Vmax |

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| CORE COURSE-**ENZYMOLOGY** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **201.1** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 |
| **201.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **201.3** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 3 |
| **201.4** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **202.1** | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 |
| **202.2** | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 3 | 3 | 3 |
| Average | 3 | 3 | 2 | 3 | 3 | 2.33 | 2.66 | 3 | 2.83 | 2.5 | 3 |

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| **CORE COURSE - BIOTECHNOLOGY-4****GENETICS** |
| **CO#** | After the successful completion of the course the student will be able to |
| **203.1** | Exhibit conceptual understanding of laws of inheritance, genetic basis of loci and alleles and their linkage.  |
| **203.2** | Comprehend the effect of chromosomal abnormalities in numerical as well as structural changes leading to genetic disorders. |
| **203.3** | Develop critical understanding of chemical basis of genes and their interactions at population and evolutionary levels. |
| **203.4** | Analyze the effect of mutations on gene functions and dosage |
| **204.1** | Identify various stages of mitotic and meiotic cell cycles |
| **204.2** | Analyze the effect of mutations on gene functions  |

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| CORE COURSE- **GENETICS** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **203.1** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 |
| **203.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **203.3** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **203.4** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **204.1** | 3 | 3 | 2 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 |
| **204.2** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 |
| Average | 3 | 3 | 2.16 | 3 | 3 | 2.33 | 2.83 | 3 | 2.83 | 2.83 | 3 |

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| **GENERIC ELECTIVE -ZOOLOGY -2****MAMMALIAN PHYSIOLOGY** |
| **CO#** | After the successful completion of the course the student will be able to |
| **201.1** | Gain in-depth understanding and appropriate functioning of digestive and cardiovascular system in animals  |
| **201.2** |  Describe the Physiology of human respiration & excretion  |
| **201.3** | Understand the functioning of nerve impulse&reflex action and will explain about different types ofmuscles and their physiology in human |
| **201.4** | Explain the mechanism of action of hormones and related molecules involved in various physiological processes and will describe about human reproductive system |
| **202.1** | analyse blood sample for total blood cell count, TLC, DLC  |
| **202.2** | Analyze urine sample and identify various tissues  |

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| **GENERIC ELECTIVE- MAMMALIAN PHYSIOLOGY** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **201.1** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 |
| **201.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 |
| **201.3** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 |
| **201.4** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 |
| **202.1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **202.2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **Average** | 3 | 3 | 2.33 | 3 | 3 | 3 | 3 | 2.33 | 3 | 2.33 | 3 |

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| **CORE COURSE - BIOTECHNOLOGY-5****METABOLISM** |
| **CO#** | After the successful completion of the course the student will be able to |
| **301.1** | Apply the knowledge of biological redox reactions, coupled reactions, energy rich compounds and the energy transactions in studying metabolism; describe the metabolic pathways *i.e.* glycolysis (catabolism), gluconeogensis (anabolism), and TCA cycle and their regulations  |
| **301.2** | Discuss the reactions, regulation and importance of pentose phosphate pathway, glycogen metabolism, glyoxylate, ETC and apply the concept of oxidative phosphorylation to calculate energy production by oxidation of carbohydrates  |
| **301.3** | Describe the reactions and regulation of lipid biosynthesis and catabolism by beta, alpha and omega oxidative pathways: ketone bodies metabolism and integration to the metabolism of other biomolecules  |
| **301.4** | Analyse how amino acid catabolism leads to formation of diverse type molecules including ketone bodies, glucose, urea: discuss the catabolism and anabolismof nucleic acids and porphyrins. |
| **302.1** | Determine biomolecules in the samples quantitatively. |
| **302.2** |  Isolate and characterize carbohydrates, lipids and proteins from the natural sources |

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| CORE COURSE- **METABOLISM** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **301.1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **301.2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **301.3** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **301.4** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **302.1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **302.2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| Average | 3 | 3 | 2.66 | 3 | 3 | 3 | 3 | 2.66 | 2.83 | 2.83 | 3 |

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| **CORE COURSE - BIOTECHNOLOGY-6****PLANT ANATOMY AND PHYSIOLOGY** |
| **CO#** | After the successful completion of the course the student will be able to |
| **303.1** | Exhibit the knowledge of fundamentals of plant anatomy and examine the internal anatomy of plant organs |
| **303.2** | Correlate the concept of water relation of plants to various physiological processes and nutrition of plants  |
| **303.3** | Explain the process and significance of Photosynthesis and nitrogen metabolism |
| **303.4** | Illustrate various phases of plant growth and factors affecting them  |
| **304.1** | Prepare stained mounts of anatomy and demonstrate physiological processes: plasmolysis, stomata opening, guttation of leaf tips,aerobic respiration |
| **304.2** | Separate photosynthetic pigments and prepare mounts of root nodules. |

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| **CORE COURSE**- **PLANT ANATOMY AND PHYSIOLOGY** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **303.1** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 |
| **303.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **303.3** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 |
| **303.4** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 |
| **304.1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **304.2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Average | 3 | 3 | 2.33 | 3 | 3 | 3 | 3 | 2.33 | 2.83 | 2.66 | 3 |

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| **GENERIC ELECTIVE -ZOOLOGY -3****DEVELOPMENTAL BIOLOGY** |
| **CO#** | After the successful completion of the course the student will be able to |
| **301.1** | Gain detail understanding of various developmental processes including gametogenesis, fertilization and different pattern and mechanism of fertilized cell cleavage,  |
| **301.2** | Understand the concept of germ layers, their formation and differentiation and will describe about early phase of embryonic development |
| **301.3** | Explain about the concept of differentiation and embryonic induction |
| **301.4** | Describe the development of organ including eye and fate of primary germ layers and will explain the process of aging & senescence in vertebrates  |
| **302.1** | Differentiate various life stages of mosquito/frog and will identify chick embryo stages |
| **302.2** | Able to prepare permanent histological slides  |

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| **GENERIC ELECTIVE- DEVELOPMENTAL BIOLOGY** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **301.1** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 |
| **301.2** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 |
| **301.3** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 |
| **301.4** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 |
| **302.1** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 |
| **302.2** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 |
| **Average** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2.16 | 2.33 | 3 |

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| **CORE COURSE - BIOTECHNOLOGY-8****MOLECULAR BIOLOGY** |
| **CO#** | After the successful completion of the course the student will be able to |
| **401.1** | Elaborate the central dogma of life at molecular level and the general principles of gene organization, DNA supercoiling; nucleases and various approaches of sequencing of DNA |
| **401.2** | Describe the structure and functions of proteins involved in replication and mechanism of DNA replication and correlate molecular basis of different types of DNA mutations with the repair systems of the mutations |
| **401.3** | Give an insight of the process of gene expression, mechanism of transcription, post-transcriptional processing of RNA in prokaryotes; Describe and correlate the concept of genetic code and mechanism of translation in prokaryotes  |
| **401.4** | Describe the process of regulation of gene expression in prokaryotes and exhibit the knowledge of basics of recombinant technology for the manipulation of genetic information stored in the cells with the help of diverse cloning vectors |
| **402.1** | Isolate and quantify genetic material from plant/animal sources by colorimetric methods |
| **402.2** | Exhibit the skill in separating the fragments of DNA by electrophoresis and characterizing by absorption spectrum. . |

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| CORE COURSE- **MOLECULAR BIOLOGY** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **401.1** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **401.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **401.3** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **401.4** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **402.1** | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 |
| **402.2** | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 |
| Average | 3 | 3 | 2.33 | 3 | 3 | 3 | 3 | 2.33 | 2.83 | 2.66 | 3 |

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| **CORE COURSE - BIOTECHNOLOGY-9****ANIMAL BIOTECHNOLOGY** |
| **CO#** | After the successful completion of the course the student will be able to |
| **403.1** | Describe the scope, application of animal biotechnology and elaborate the techniques of gene transfer in mammalian cells  |
| **403.2** | Explain the concept of animal transgenesis and their applications in pathogenesis |
| **403.3** | Describe about cloning, artificial insemination, their role in animal propagation and will understand the role of biotechnology including IVF and stem cells in conservations of livestock diversity  |
| **403.4** | Elaborate the gene therapy, its type and their role in bioengineering |
| **404.1** | Prepare different media, culture and cryopreserve the animal cells. |
| **404.2** | Perform gene transfer technique and demonstrate about animal cloning and IVF. . |

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| CORE COURSE- **ANIMAL BIOTECHNOLOGY** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **403.1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **403.2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **403.3** | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 |
| **403.4** | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 |
| **404.1** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 2 | 3 | 3 |
| **404.2** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 |
| Average | 3 | 3 | 3 | 3 | 3 | 2.33 | 2.66 | 3 | 2.83 | 2.66 | 3 |

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| **GENERIC ELECTIVE -ZOOLOGY -4****ANIMAL DIVERSITY** |
| **CO#** | After the successful completion of the course the student will be able to |
| **401.1** | Describe unique characters, diversity and ecological role of phylum Protozoa, Porifera, Coelenterate & Helminthes  |
| **401.2** | Explain in detail about the characters, diversity and ecological role of phylum Arthropoda, Mollusca&Echinodermata |
| **401.3** | Identify different Urochordates, Cephalochordates, about their adaptations and associations in relation to their environment.  |
| **401.4** | Identify (based on morphological characters) and understand adaptations in vertebrate class including amphibians, reptiles, birds, and mammals |
| **402.1** | Identify invertebrates and vertebrate specimeas well as classify them |
| **402.2** | Prepare slides of different parts as was whole mounts of vertebrate and Invertebrate  |

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| **GENERIC ELECTIVE- ANIMAL DIVERSITY** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **401.1** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 |
| **401.2** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 |
| **401.3** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 |
| **401.4** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 |
| **402.1** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 |
| **402.2** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 |
| **Average** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 2 | 2 | 2 |  |

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| **CORE COURSE – BIOTECHNOLOGY-11****RECOMBINANT DNA TECHNOLOGY** |
| **CO#** | After the successful completion of the course the student will be able to |
| **501.1** | Understand the concept and scopes of Genetic Engineering and central role of recombinant DNA technology in all fields of Biotechnology |
| **501.2** | Learn about enzymes, vectors, and their types to be used in the recombinant DNA technology |
| **501.3** | Describe about different methodologies to be used for the isolation and analysis of genomic and nuclear DNA |
| **501.4** | Illustrate about the PCR, their types along with strategies required for gene cloning purpose including preparation of competent cell, introduction of foreign DNAs into competent cells and selection of recombinants |
| **502.1** | Isolate nucleic acids, quantify and analyze by gel electrophoresis. |
| **502.2** | Exhibit the skill in designing primers and exploring restriction enzymes by using online database and will also carry out restriction digestion and perform PCR based analysis to study recombinant genes. |

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| CORE COURSE- **RECOMBINANT DNA TECHNOLOGY** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **501.1** | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **501.2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **501.3** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **501.4** | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **502.1** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 2 | 3 | 3 |
| **502.2** | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| Average | 3 | 3 | 3 | 3 | 3 | 2.33 | 2.83 | 3 | 2.83 | 3 | 3 |

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| **CORE COURSE - BIOTECHNOLOGY-12****PLANT BIOTECHNOLOGY** |
| **CO#** | After the successful completion of the course the student will be able to |
| **503.1** | Elaborate the concept of plant tissue culture, totipotency, differentiation and somaclonal variation.. |
| **503.2** | Describe different techniques of micropropagation in plants, their applications and limitations |
| **503.3** | Give an insight of vector mediated and vectorless methods of plant cell transformation, along with merits and demerits. |
| **503.4** | Correlate the plant genome organization with different types of transformations  |
| **504.1** | Prepare and sterilize different media required for plant tissue culture |
| **504.2** | Perform micro-propagation with different explants.. |

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| CORE COURSE- **PLANT BIOTECHNOLOGY** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **503.1** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **503.2** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **503.3** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **503.4** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **504.1** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 2 | 3 | 3 |
| **504.2** | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| Average | 3 | 3 | 2.33 | 3 | 3 | 2.33 | 2.83 | 3 | 2.83 | 3 | 3 |

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| **DISCIPLINE SPECIFIC ELECTIVE- BIOTECHNOLOGY-1****FOOD TECHNOLOGY** |
| **CO#** | After the successful completion of the course the student will be able to |
| **505.1** | Gain the knowledge about different food and dietary supplements such as food from fungi, algae and bacteria and their large scale production and genetically modified (GM) foods.  |
| **505.2** | Learn about food additives & its classification and functions along with diverse methods of food preservation. |
| **505.3** | Understand about various packing materials, their properties and functioning in food industries  |
| **505.4** | Learn the concept of safety, quality assurance and food adulteration along with the role of national and international food regulatory bodies their standards for maintaining food quality and safety. |
| **506.1** | check the quality of packed and unpacked foods and role of preservation techniques  |
| **506.2** | Analyse the unknown samples qualitatively for the presence of various biomolecules |

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| **DISCIPLINE SPECIFIC ELECTIVE** - **FOOD TECHNOLOGY** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **505.1** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **505.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **505.3** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **505.4** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **506.1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **506.2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **Average** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2.33 | 3 |

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| **DISCIPLINE SPECIFIC ELECTIVE - BIOTECHNOLOGY-1****BIOMATHEMATICS** |
| **CO#** | After the successful completion of the course the student will be able to |
| **507.1** | Understand the basics of mathematics and its use in biological sciences.  |
| **507.2** | Learn about complex numbers and matrices which can help them to understand various biological models involving variables i.e. frequencies of multiple alleles, population dyanamics, image processing and bioinformatics etc. |
| **507.3** | Learn about differential equation and its application which can be used in modeling. |
| **507.4** | Gain knowledge related to partial differential equations which help them to understand regulatory feedbacks and transport processes in multicellular biological systems |
| **508.1** | apply operation on complex number and matrices |
| **508.2** | apply composite functions and differential equation  |

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| **DISCIPLINE SPECIFIC ELECTIVE** - **BIOMATHEMATICS**  |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **507.1** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 |
| **507.2** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 |
| **507.3** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 |
| **507.4** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 |
| **508.1** | 3 | 3 | 1 | 3 | 3 | 1 | 2 | 2 | 2 | 3 | 3 |
| **508.2** | 3 | 3 | 1 | 3 | 3 | 1 | 2 | 2 | 2 | 3 | 3 |
| **Average** | 3 | 3 | 1.66 | 3 | 3 | 1.66 | 2.66 | 2.5 | 2 | 3 | 3 |

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| **DISCIPLINE SPECIFIC ELECTIVE - BIOTECHNOLOGY-2****MEDICAL BIOTECHNOLOGY**  |
| **CO#** | After the successful completion of the course the student will be able to |
| **511.1** | Understand chromosomal, gene and mitochondrial disorders and will describe about various biotechnology tools to detect these disorders. |
| **511.2** | Learn about various invasive and non-invasive techniques to diagnose human disorders during prenatal period. |
| **511.3** | Understand metabolic disorders and their management by using diverse therapeutic approaches. |
| **511.4** | Describe and appraise broad knowledge of the use of gene products as vaccines |
| **512.1** | analyse DNA damage and modifications  |
| **512.2** | give an insight of development of disease causing agents and diagnostic tools |

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| **DISCIPLINE SPECIFIC ELECTIVE** - **MEDICAL BIOTECHNOLOGY**  |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **511.1** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **511.2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **511.3** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **511.4** | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 |
| **512.1** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 |
| **512.2** | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **Average** | 3 | 3 | 2 | 3 | 3 | 2.5 | 2.83 | 3 | 3 | 2.33 | 3 |

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| **GENERIC ELECTIVE -ZOOLOGY -5****EVOLUTIONARY BIOLOGY** |
| **CO#** | After the successful completion of the course the student will be able to |
| **501.1** | Understand the conditions conducive for origin of life on earth and also about various theories related to origin of life and evolutionary biology.  |
| **501.2** | Differentiate between micro, macro and mega evolution and will understand interrelation amongst various species and can develop the phylogeny trees accordingly |
| **501.3** | Explain the concept of variations in the species and will describe about the population genetics and role of migration and mutation in the evolution |
| **501.4** | Understand the concept of selection, types and their impact on evolution |
| **502.1** | Understand the process of adaptations and variations  |
| **502.2** | Identify fossils |

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| **GENERIC ELECTIVE- EVOLUTIONARY BIOLOGY** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **501.1** | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 |
| **501.2** | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 |
| **501.3** | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 |
| **501.4** | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 |
| **502.1** | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 |
| **502.2** | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 |
| **Average** | 3 | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 2.33 | 3 |

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| **CORE COURSE - BIOTECHNOLOGY-13****GENOMICS & PROTEOMICS** |
| **CO#** | After the successful completion of the course the student will be able to |
| **601.1** | Determine the function of genes and elements that regulate genes throughout the genome and apply sequence for analysis of organism genome. |
| **601.2** | Perform on various web based softwares for genome analysis |
| **601.3** | Correlate the findings of protein techniques to the structures of proteins |
| **601.4** | Analyse proteomes using various tools and techniques  |
| **602.1** | Perform on various databases of genome analysis by using online tools. |
| **602.2** | Perform on various tools of proteome analysis |

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| CORE COURSE- **GENOMICS & PROTEOMICS** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **601.1** | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 |
| **601.2** | 3 | 3 | 1 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 |
| **601.3** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **601.4** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **602.1** | 3 | 3 | 1 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **602.2** | 3 | 3 | 1 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| Average | 3 | 3 | 1.66 | 3 | 3 | 1.66 | 3 | 3 | 3 | 3 | 3 |

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| **CORE COURSE - BIOTECHNOLOGY-14****IPR, BIOETHICS AND BIOSAFETY**  |
| **CO#** | After the successful completion of the course the student will be able to |
| **603.1** | Learn the concept of Intellectual property rights, national institutes belonging to the IPRs, patent laws, IPR’s regulatory affairs and their applications in modern world and also will understand about commercialization of inventions in the biotechnology sector |
| **603.2** | Understand about start-ups and business strategies by taking account of IPRs and will gain the importance of innovative research |
| **603.3** | Understand the concepts, its laws and the importance of regulatory bodies in bioethics and will describe about ethical practices appropriate to the scientific disciplines at all times |
| **603.4** | Gain the concept about the biosafety, its levels and government guidelines while working with microorganisms, animal blood/tissue/cells, other hazardous & non-hazardous samples and will understand about other safe working practices relevant to the fields of research & different biotechnology industries. |
| **604.1** | Demonstrate the knowledge of the intellectual property rights and its utility in the securing inventor’s rights against new innovation and in initiating start-ups |
| **604.2** | Exhibits skill when and how to handle biological and non-biological; hazardous and non-hazardous samples |

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| CORE COURSE- **IPR, BIOETHICS AND BIOSAFETY**  |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **P6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **603.1** | 3 | 3 | 2 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 |
| **603.2** | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 |
| **603.3** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **603.4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **604.1** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **604.2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Average | 3 | 3 | 2.66 | 3 | 3 | 2.16 | 3 | 3 | 3 | 3 | 3 |

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| **DISCIPLINE SPECIFIC ELECTIVE - BIOTECHNOLOGY-3****IMMUNOLOGY** |
| **CO#** | After the successful completion of the course the student will be able to |
| **605.1** | Exhibit the knowledge of basic components |
| **605.2** | Illustrate the attributes of antigens |
| **605.3** | Explain the mechanisms generating diversity and specificity in immune system alongwith principles and applications of several immunotools (RIA, ELISA, FACS etc) which can be used to quantify the interaction between antigen and antibody of the immune system. |
| **605.4** | Describe about the immunization |
| **606.1** | perform various immunoassays such as Radial immunoassay FACS |
| **606.2** |  separate and quantify proteins from blood/serum/ plasma samples |

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| **DISCIPLINE SPECIFIC ELECTIVE** - **IMMUNOLOGY** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **605.1** | 3 | 3 | 1 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 |
| **605.2** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 |
| **605.3** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **605.4** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **606.1** | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **606.2** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 |
| **Average** | 3 | 3 | 2.16 | 3 | 3 | 2.33 | 2.83 | 3 | 3 | 2.5 | 3 |

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| **DISCIPLINE SPECIFIC ELECTIVE - BIOTECHNOLOGY-3****BIOINFORMATICS** |
| **CO#** | After the successful completion of the course the student will be able to |
| **607.1** | Understand the fundamentals, importance and limitation of bioinformatics and biological databases. |
| **607.2** | Describe the concept of sequence alignment, its types and importance of scoring matrices and will understand about bioinformatics tools such as BLAST, FASTA, clustal-w etc. that will help in generating accurate prediction about gene and its product. |
| **607.3** | Learn about molecular phylogenetic tools which will help to depict the probable evolution of various organisms by building a "relationship tree". |
| **607.4** | Learn about biological macromolecular structures and structure prediction methods. |
| **608.1** | search, use and download various biological database |
| **608.2** | perform prokaryotic, eukaryotic gene analysis: prosite, motif and rna structure prediction |

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| **DISCIPLINE SPECIFIC ELECTIVE** - **BIOINFORMATICS** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **607.1** | 3 | 3 | 1 | 3 | 3 | 1 | 2 | 3 | 2 | 3 | 3 |
| **607.2** | 3 | 3 | 1 | 3 | 3 | 1 | 2 | 3 | 2 | 3 | 3 |
| **607.3** | 3 | 3 | 1 | 3 | 3 | 2 | 2 | 3 | 2 | 3 | 3 |
| **607.4** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 2 | 3 |
| **608.1** | 3 | 3 | 2 | 3 | 3 | 2 | 2 | 3 | 2 | 3 | 3 |
| **608.2** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 2 | 3 | 3 |
| **Average** | 3 | 3 | 1.66 | 3 | 3 | 1.66 | 2.16 | 3 | 2 | 2.83 | 3 |

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| **DISCIPLINE SPECIFIC ELECTIVE - BIOTECHNOLOGY-4****MOLECULAR DIAGNOSTICS**  |
| **CO#** | After the successful completion of the course the student will be able to |
| **609.1** | Know about uses of enzymes and antibodies (monoclonal & polyclonal) for diverse immunooassays and their applications in medical diagnostic purpose |
| **609.2** | Gain the knowledge of various molecular approaches (PCR, RFLP etc.) and chemotherapy tests which can be used in clinical testing. |
| **609.3** | Explain about automation in microbial diagnosis and other rapid diagnostic approaches based on the concept of idiotypes. |
| **609.4** | Describe and appraise various diagnostic tools which can help to study in details about cell biology such as RIA, immunoflorescence, chromatrography, microscopy etc and associated with medical science. |
| **610.1** | use different diagnostic tools like Immunobloting, PCR, PAGE etc. |
| **610.2** | quantify cells by cytometry, nucleic acid by southern hybridization and determine MIC |

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| **DISCIPLINE SPECIFIC ELECTIVE** - **MOLECULAR DIAGNOSTICS** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **609.1** | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **609.2** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **609.3** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **609.4** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **610.1** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **610.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **Average** | 3 | 3 | 2.33 | 3 | 3 | 2.5 | 3 | 3 | 3 | 3 | 3 |

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| **GENERIC ELECTIVE -ZOOLOGY -6****ECOLOGY AND ENVIRONMENT MANAGEMENT** |
| **CO#** | After the successful completion of the course the student will be able to |
| **601.1** | Understand the basic concepts of ecology and will describe about various factors including abiotic and biotic which affect environment.  |
| **601.2** | Describe about ecosystem, ecological energetic, energy flow and biogeochemical cycles. |
| **601.3** | Explain about the biodiversity conservation of natural resources and population ecology |
| **601.4** | Understand different types of pollution, impact on environment and their management strategies. |
| **602.1** | Measure various physio-chemical parameters of water samples  |
| **602.2** | Document biodiversity |

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| **GENERIC ELECTIVE- ECOLOGY AND ENVIRONMENT MANAGEMENT** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **601.1** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 |
| **601.2** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **601.3** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **601.4** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **602.1** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **602.2** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **Average** | 3 | 3 | 1.16 | 3 | 3 | 3 | 3 | 2 | 3 | 2.83 | 3 |

**Programme Outcomes for PG courses of Faculty of Life Sciences**

**PO1**: To acquaint students with recent knowledge and techniques in basic and applied biological sciences.

**PO2**: To develop understanding of organismal, cellular, biochemical and environmental basis of life

**PO3**: To provide insight into ethical implications of biological research for environmental protection and good laboratory practices and biosafety.

**PO4**:To develop problem solving innovative thinking with robust communication and writing skills in youth with reference to biological ,environmental and nutritional sciences.

**PO5:** To understand application of biotic material in health, medicine, food security for human well-being and sustainable development.

**PO6**: To impart practical and project based vocational training for preparing youth for a career in research and entrepreneurship in fields of life sciences for self-reliance.

**Programme specific Outcomes for PG courses in Biotechnology**

After the successful completion of the programme the student will be able to

**PSO1**: acquaint with theoretical and practical knowledge in different areas of Biotechnology. They will be able to understand various biological aspects and will develop into Biotech savvy integrated personalities with scientific thinking.

**PSO2**: analyze, solve problems related to Biotechnology fields. They will be able to launch startups, become entrepreneurs for novel biotechnology products and processes in various industries

**PSO3**: understand biosafety measures, ethical issues and regulatory compliances in Biotechnology

**PSO4**: communicate effectively, work independently, imbibe the values of team spirit, write execute and manage their research project.

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| **CORE COURSE - BIOTECHNOLOGY-15****ADVANCED MOLECULAR BIOLOGY** |
| **CO#** | After the successful completion of the course the student will be able to |
| **701.1** | Understand the concepts of gene regulation in prokaryotes, the importance of E. coli lac & trp operon models along with gene expression regulation in lamda phages |
| **701.2** | Learn about diverse regulatory sequences, transcriptional, post-transcriptional, translational and post-translation regulations in eukaryotes |
| **701.3** | Describe the concept of transposable elements and their role in living systems including in viruses and will understand about RNAs world which includes siRNAs & miRNAs and their potential as a gene silencing and therapeutic agent |
| **701.4** | Explain types of cancer, cancer causing agents, proto-oncogenes and mechanism for the activation of proto-oncogenes into oncogenes. |
| **702.1** | Isolate, quantify and analyze plant histone proteins using various techniques including microscopy & electrophoresis |
| **702.2** | Use diverse online tools to explore promoter sequences in given prokaryotic/ eukaryotic genes |

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| **CORE COURSE - ADVANCED MOLECULAR BIOLOGY** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **701.1** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 3 |
| **701.2** | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 |
| **701.3** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **701.4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **702.1** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **702.2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Average | 3 | 3 | 2.66 | 3 | 3 | 2.66 | 3 | 3 | 2.66 | 3 |

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| **CORE COURSE - BIOTECHNOLOGY-16****BIOPROCESS AND FERMENTATION TECHNOLOGY** |
| **CO#** | After the successful completion of the course the student will be able to |
| **703.1** | Describe the techniques of isolation, screening and improvement of industrially important microbial strains. |
| **703.2** | Describe the designing of a bioreactor with different modifications |
| **703.3** | Give an insight of upstream and downstream processing |
| **703.4** | Explore applications and achievements of fermentation technology in the field of medicine. |
| **704.1** | Isolate economically important microbes from environment and perform biomass and metabolite production in microbial cultures. |
| **704.2** | Demonstrate analysis of produced metabolites  |

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| **CORE COURSE - BIOPROCESS AND FERMENTATION TECHNOLOGY** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **703.1** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **703.2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **703.3** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **703.4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **704.1** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **704.2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Average | 3 | 3 | 2.66 | 3 | 3 | 3 | 3 | 3 | 2.66 | 3 |

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| **CORE COURSE - BIOTECHNOLOGY-17****BIOSTATISTICS** |
| **CO#** | After the successful completion of the course the student will be able to |
| **705.1** | Comprehend the fundamental concepts related to descriptive and inferential biostatistics. |
| **705.2** | Develop skills in data tabulation, its treatment, analysis, interpretation and graphical representation of data. |
| **705.3** | Analyze the implications of inferential statistics in biology.  |
| **705.4** | Develop their competence in hypothesis testing and interpretation |
| **706.1** | Solve the problems based on graphical Representation and measures of Central Tendency & Dispersion. |
| **706.2** | Solve the problems based on Distributions Binomial Poisson Normal, t, f, z and Chi-square  |

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| **CORE COURSE - BIOSTATISTICS** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **705.1** | 3 | 3 | 1 | 3 | 3 | 2 | 3 | 2 | 1 | 3 |
| **705.2** | 3 | 3 | 1 | 3 | 3 | 2 | 3 | 2 | 1 | 3 |
| **705.3** | 3 | 3 | 1 | 3 | 3 | 2 | 3 | 2 | 1 | 3 |
| **705.4** | 3 | 3 | 1 | 3 | 3 | 2 | 3 | 2 | 1 | 3 |
| **706.1** | 3 | 3 | 1 | 3 | 3 | 2 | 3 | 2 | 1 | 3 |
| **706.2** | 3 | 3 | 1 | 3 | 3 | 2 | 3 | 2 | 1 | 3 |
| Average | 3 | 3 | 1 | 3 | 3 | 2 | 3 | 2 | 1 | 3 |

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| **DISCIPLINE SPECIFIC ELECTIVE- BIOTECHNOLOGY-5****NANOTECHNOLOGY** |
| **CO#** | After the successful completion of the course the student will be able to |
| **707.1** | Describethe basic fundamentals of nanobiotechnology with detail understanding of different nanomaterials, their types and properties. |
| **707.2** | Acquire the knowledge on different nano-fabarication methods and will be skilled in various visualization and characterization techniques requires for nanomaterials. |
| **707.3** | Understand about the principles of interaction of biomolecules to the surfaces of different nanomaterials and their relevance in the biomedical sciences. |
| **707.4** | Explain use of nanoparticals in medical care and will understand the possible impact of nanotechnology on society, industry and environment. |
| **708.1** | Synthesize nanoparticals by diverse methods |
| **708.2** | characterize nanoparticals byUV-Vis, FTIR, XRD and prepare samples for electron microscopy |

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| **DISCIPLINE SPECIFIC ELECTIVE- NANOTECHNOLOGY** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **707.1** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **707.2** | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **707.3** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **707.4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **708.1** | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 |
| **708.2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **Average** | 3 | 3 | 2.16 | 3 | 3 | 2.83 | 3 | 3 | 2.66 | 3 |

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| **DISCIPLINE SPECIFIC ELECTIVE- BIOTECHNOLOGY-5****MEDICINAL MICROBIOLOGY** |
| **CO#** | After the successful completion of the course the student will be able to |
| **709.1** | Describe basic principles of medical microbiology |
| **709.2** | Understand the morphology |
| **709.3** | Explain about viral pandemic |
| **709.4** | Understand the importance of pathogenic microorganisms (fungal and protozoan) in human disease with respect to systemic |
| **710.1** | Isolate and characterize pathogens from clinical samples |
| **710.2** | determine antibacterial activity by different methods |

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| **DISCIPLINE SPECIFIC ELECTIVE- MEDICINAL MICROBIOLOGY** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **709.1** | 3 | 3 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 3 |
| **709.2** | 3 | 3 | 3 | 2 | 3 | 2 | 3 | 2 | 2 | 3 |
| **709.3** | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 |
| **709.4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **710.1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **710.2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **Average** | 3 | 3 | 3 | 2.66 | 3 | 2.5 | 3 | 2.66 | 2.66 | 3 |

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| **CORE COURSE - BIOTECHNOLOGY-18****ADVANCED RECOMBINANT DNA TECHNOLOGY** |
| **CO#** | After the successful completion of the course the student will be able to |
| **801.1** | Learn in-depth understanding about gene library and their types along with diverse procedures required for selection of rDNA clones and their expression products including In-situ hybridization and Protein-protein interactions |
| **801.2** | Understand the concept of mutagenesis, types and their impact on gene modification. |
| **801.3** | Learn about different approaches to be used for studying gene expression, its regulation and manipulation of recombinant gene expression in Prokaryotes |
| **801.4** | Describe about heterologous protein production in diverse eukaryotic cell systems and will elucidate wide applications of rDNA technology including in medical care and food industry  |
| **802.1** | Exhibit the skill to study any damage and mutations in the isolated DNA |
| **802.2** | Demonstrate analysis of Cre-Lox and CRISPR/Cas9 systems used for production of recombinant gene products. |

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| **CORE COURSE - ADVANCED RECOMBINANT DNA TECHNOLOGY** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **801.1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **801.2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **801.3** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **801.4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **802.1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **802.2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Average | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

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| **CORE COURSE - BIOTECHNOLOGY-19****ANIMAL CELL CULTURE** |
| **CO#** | After the successful completion of the course the student will be able to |
| **803.1** | Describe the biology of cultured cells and basic requirements of animal cell culture |
| **803..2** | Elaborate the diverse media require for animal cell culture with their merits & demerits and will extend the diverse applications of animal cell culture. |
| **803.3** | Illustrate about the primary cell culture, sub-culture along with various parameters of cell line characterizations |
| **803.4** | Understand the concept of cell cloning, techniques to scale up production of cell, organ culture and will explain diverse types of stem cells including satellite cells, iPS and their impact in future therapy against incurable diseases |
| **804.1** | Prepare and sterilize media used in animal cell culture |
| **804.2** | Culture, check viability, iPS and animal cell culture process  |

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| **CORE COURSE - ANIMAL CELL CULTURE** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **803.1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **803..2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **803.3** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **803.4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **804.1** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| **804.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| Average | 3 | 3 | 2.66 | 3 | 3 | 3 | 3 | 3 | 2.66 | 3 |

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| **CORE COURSE - BIOTECHNOLOGY-20****BIOENTERPRENEURSHIP DEVELOPMENT** |
| **CO#** | After the successful completion of the course the student will be able to |
| **805.1** | Exhibit the knowledge of structure, management and role of innovations in an organization |
| **805..2** | Discuss the government schemes for commercialization of biotechnology |
| **805.3** | Describe various elements of operational research and management |
| **805.4** | Compare and analyse the characteristics of biotech enterprises, various parameters of quality control and government regulations |
| **806.1** | Analyse his personality and ability as an entrepreneur |
| **806.2** | Plan and analyse the requirement and status of Biotech industry |

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| **CORE COURSE - BIOENTERPRENEURSHIP DEVELOPMENT** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **805.1** | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 3 |
| **805..2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **805.3** | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **805.4** | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **806.1** | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 3 |
| **806.2** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Average | 3 | 3 | 2.66 | 3 | 2.33 | 3 | 3 | 3 | 2.66 | 3 |

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| **CORE COURSE - BIOTECHNOLOGY-21****BIOINSTRUMENTATION** |
| **CO#** | After the successful completion of the course the student will be able to |
| **901.1** | Describe the principles and types of various techniques like spectroscopy, centrifugation and chromatography |
| **901.2** | Elaborate the applications of advanced techniques in isolation and purification of biomolecules |
| **901.3** | Describe the principles and applications of various techniques of multiplication and characterization of nucleic acids |
| **901.4** | Give an insight of applications of immunotechniques and biosensors |
| **902.1** | Isolate subcellular organelles from animal and plant tissues. |
| **902.2** | Perform electrophoresis, zymography and analyse the results |

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| **CORE COURSE - BIOINSTRUMENTATION** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **901.1** | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 3 |
| **901.2** | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **901.3** | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **901.4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **902.1** | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **902.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| Average | 3 | 3 | 2.66 | 3 | 2.33 | 3 | 3 | 3 | 2.66 | 3 |

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| **CORE COURSE - BIOTECHNOLOGY-22****RESEARCH METHODOLOGY** |
| **CO#** | After the successful completion of the course the student will be able to |
| **903.1** | Elaborate the concept of research and different types of research in the context of biology  |
| **903.2** | Develop laboratory experiment related skills.  |
| **903.3** | Develop competence on data collection and process of scientific documentation |
| **903.4** | Analyze the ethical aspects of research and evaluate the different methods of scientific writing, reporting and focuses on plagiarism |
| **904.1** | Design, plan and write up the research proposals |
| **904.2** | Demonstrate skill in critically analyzing the observations to draw inference |

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| **CORE COURSE RESEARCH METHODOLOGY** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **903.1** | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **903.2** | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **903.3** | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 3 |
| **903.4** | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **904.1** | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 3 |
| **904.2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| Average | 3 | 3 | 2.3 | 3 | 2.16 | 3 | 3 | 3 | 2.3 | 3 |

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| **CORE COURSE - BIOTECHNOLOGY-23****ENVIORNMENTAL BIOTECHNOLOGY**  |
| **CO#** | After the successful completion of the course the student will be able to |
| **905.1** | Describe various dimensions of ecology, biodiversity and their importance. |
| **905.2** | Analyse the causes of air pollution and their control mechanisms.  |
| **905.3** | Analyse the causes of water pollution and their control mechanisms using biotechnological processes |
| **905.4** | Give an insight of application of biosources as the solution to various environmental concerns |
| **906.1** | Qualitatively analyse the soil samples and isolate microbes from soil |
| **906.2** | Analyse the water samples for TDS, DO and COD |

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| **CORE COURSE - ENVIORNMENTAL BIOTECHNOLOGY** |
| **CO#** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PSO1** | **PSO2** | **PSO3** | **PSO4** |
| **905.1** | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 3 |
| **905.2** | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 3 |
| **905.3** | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 3 |
| **905.4** | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 3 |
| **906.1** | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 3 |
| **906.2** | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 3 |
| Average | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 2 | 3 |