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| M.SC.,bioinformaticsClinical Trial Management |
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| **SYLLABUS** |
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| **from the academic year****2023 – 2024** |
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| **TAMILNADU STATE COUNCIL FOR HIGHER EDUCATION, CHENNAI – 600 005** |
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| **TANSCHE REGULATIONS ON LEARNING OUTCOMES-BASED CURRICULUM FRAMEWORK FOR POSTGRADUATE EDUCATION** |
| **Programme** | **M.Sc. BIO-INFORMATICS AND CLINICAL TRIAL MANAGEMENT** |
| **Programme Code** |  |
| **Duration** | **2 years for PG** |
| **Programme Outcomes (Pos)** | **PO1: Problem Solving Skill**Apply knowledge of Management theories and Human Resource practices to solve business problems through research in Global context.**PO2: Decision Making Skill**Foster analytical and critical thinking abilities for data-based decision-making.**PO3: Ethical Value**Ability to incorporate quality, ethical and legal value-based perspectives to all organizational activities.**PO4: Communication Skill**Ability to develop communication, managerial and interpersonal skills.**PO5: Individual and Team Leadership Skill**Capability to lead themselves and the team to achieve organizational goals.**PO6: Employability Skill**Inculcate contemporary business practices to enhance employability skills in the competitive environment.**PO7: Entrepreneurial Skill**Equip with skills and competencies to become an entrepreneur.**PO8: Contribution to Society** Succeed in career endeavors and contribute significantly to society.**PO 9 Multicultural competence** Possess knowledge of the values and beliefs of multiple cultures and  a global perspective.**PO 10: Moral and ethical awareness/reasoning** Ability to embrace moral/ethical values in conducting one’s life.  |
| **Programme Specific Outcomes****(PSOs)** | **PSO1 – Placement**To prepare the students who will demonstrate respectful engagement with others’ ideas, behaviors, beliefs and apply diverse frames of reference to decisions and actions.**PSO 2 - Entrepreneur**To create effective entrepreneurs by enhancing their critical thinking, problem solving, decision making and leadership skill that will facilitate startups and high potential organizations.**PSO3 – Research and Development**Design and implement HR systems and practices grounded in research that comply with employment laws, leading the organization towards growth and development.**PSO4 – Contribution to Business World**To produce employable, ethical and innovative professionals to sustain in the dynamic business world.**PSO 5 – Contribution to the Society**To contribute to the development of the society by collaborating with stakeholders for mutual benefit. |

**Template for P.G., Programmes**

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Semester–I** | **Credit** | **Hours** | **Semester-II** | **Credit** | **Hours** | **Semester-III** | **Credit** | **Hours** | **Semester–IV** | **Credit** | **Hours** |
| 1.1. Core-I  | 5 | 7 | 2.1. Core-IV  | 5 | 6 | 3.1. Core-VII | 5 | 6 | 4.1. Core-XI  | 5 | 6 |
| 1.2 Core-II  | 5 | 7 | 2.2 Core-V  | 5 | 6 | 3.2 Core-VII  | 5 | 6 | 4.2 Core-XII | 5 | 6 |
| 1.3 Core – III  | 4 | 6 | 2.3 Core – VI | 4 | 6 | 3.3 Core – IX | 5 | 6 | 4.3 Project with viva voce | 7 | 10 |
| 1.4 Discipline Centric Elective -I | 3 | 5 | 2.4 Discipline Centric Elective – III | 3 | 4 | 3.4 Core – X  | 4 | 6 | 4.4Elective - VI (Industry / Entrepreneurship) 20% Theory80% Practical  | 3 | 4 |
| 1.5 Generic Elective-II:  | 3 | 5 | 2.5 Generic Elective -IV:  | 3 | 4 | 3.5 Discipline Centric Elective - V  | 3 | 3 | 4.5 Skill Enhancement course / Professional Competency Skill  | 2 | 4 |
|  |  |  | 2.6 NME I | 2 | 4 | 3.6 NME II | 2 | 3 | 4.6 Extension Activity | 1 |  |
|  |  |  |  |  |  | 3.7 Internship/ Industrial Activity | 2 | - |  |  |  |
|  | **20** | **30** |  | **22** | **30** |  | **26** | **30** |  | **23** | **30** |
| **Total Credit Points -91** |

**Choice Based Credit System (CBCS), Learning Outcomes Based Curriculum Framework (LOCF) Guideline Based Credits and Hours Distribution System**

**for all Post – Graduate Courses including Lab Hours**

**First Year – Semester – I**

|  |  |  |  |
| --- | --- | --- | --- |
| **Part** | **List of Courses** | **Credits** | **No. of Hours** |
|  | Core – I | 5 | 7 |
| Core – II | 5 | 7 |
| Core – III | 4 | 6 |
| Elective – I | 3 | 5 |
| Elective – II | 3 | 5 |
|  |  | **20** | **30** |

**Semester-II**

|  |  |  |  |
| --- | --- | --- | --- |
| **Part** | **List of Courses** | **Credits** | **No. of Hours** |
|  | Core – IV | 5 | 6 |
| Core – V | 5 | 6 |
| Core – VI | 4 | 6 |
| Elective – III | 3 | 4 |
| Elective – IV | 3 | 4 |
| Skill Enhancement Course [SEC] - I | 2 | 4 |
|  |  | **22** | **30** |

**Second Year – Semester – III**

|  |  |  |  |
| --- | --- | --- | --- |
| **Part** | **List of Courses** | **Credits** | **No. of Hours** |
|  | Core – VII | 5 | 6 |
| Core – VIII | 5 | 6 |
| Core – IX | 5 | 6 |
| Core (Industry Module) – X | 4 | 6 |
| Elective – V | 3 | 3 |
| Skill Enhancement Course - II | 2 | 3 |
|  | Internship / Industrial Activity [Credits] | 2 | - |
|  |  | **26** | **30** |

**Semester-IV**

|  |  |  |  |
| --- | --- | --- | --- |
| **Part** | **List of Courses** | **Credits** | **No. of Hours** |
|  | Core – XI | 5 | 6 |
| Core – XII | 5 | 6 |
| Project with VIVA VOCE | 7 | 10 |
| Elective – VI (Industry Entrepreneurship)  | 3 | 4 |
| Skill Enhancement Course – III / Professional Competency Skill | 2 | 4 |
| Extension Activity | 1 | - |
|  |  | **23** | **30** |

**Total 91 Credits for PG Courses**

* **First Year**
* **Semester – I**

|  |  |  |  |
| --- | --- | --- | --- |
| **Part** | **List of Courses** | **Credits** | **No. of Hours** |
|  | Core – I - **STRUCTURE, SYNTHESIS, REGULATION & CELLULAR FUNCTIONS OF MACROMOLECULES** | 5 | 7 |
| Core – II - **PRINCIPLES OF BIOTECHNOLOGY**  | 5 | 7 |
| Core – III - **APPLICATION OF PROGRAMMING FOR BIOLOGY-I (PRACTICALS)** | 4 | 6 |
| Elective – I **- MATHEMATICAL & STATISTICAL METHODS FOR BIOLOGISTS (OR) AND PRINCIPLES OF COMPUTATIONAL BIOLOGY AND BIOLOGICAL DATABASES** | 3 | 5 |
| Elective – II - **CELL BIOLOGY** | 3 | 5 |
|  |  | **20** | **30** |

* **Semester-II**

|  |  |  |  |
| --- | --- | --- | --- |
| **Part** | **List of Courses** | **Credits** | **No. of Hours** |
|  | Core – IV - **BASIC PRINCIPLES OF CLINICAL TRIALS** | 5 | 6 |
| Core – V - **GENOMICS AND PROTEOMICS** | 5 | 6 |
| Core – VI - **PRACTICALS RELATED TO PAPERS I & II** | 4 | 6 |
| Elective – III - **APPLICATION OF PROGRAMMING FOR BIOLOGY– II** | 3 | 4 |
| Elective – IV - **PHARMACOGENOMICS OR BIOINFORMATICS AND DRUG DESIGN** | 3 | 4 |
| Skill Enhancement Course [SEC] - I | 2 | 4 |
|  |  | **22** | **30** |

* **Second Year – Semester – III**

|  |  |  |  |
| --- | --- | --- | --- |
| **Part** | **List of Courses** | **Credits** | **No. of Hours** |
|  | Core – VII - **MOLECULAR MODELING, METHODS AND APPLICATIONS** | 5 | 6 |
| Core – VIII - **CHEMINFORMATICS** | 5 | 6 |
| Core – IX - **DATA MANAGEMENT AND REGULATORY REQUIREMENTS OF CLINICAL TRIAL** | 5 | 6 |
| Core (Industry Module) – X **TOOLS AND THEIR APPLICATION IN BIOINFORMATICS (PRACTICALS)** | 4 | 6 |
| Elective – V - **MEDICAL INFORMATICS (OR) POTENTIAL APPLICATIONS AND COMMERCIAL ASPECTS OF BIOINFORMATICS** | 3 | 3 |
| Skill Enhancement Course - II | 2 | 3 |
|  | Internship / Industrial Activity [Credits] | 2 | - |
|  |  | **26** | **30** |

* **Semester-IV**

|  |  |  |  |
| --- | --- | --- | --- |
| **Part** | **List of Courses** | **Credits** | **No. of Hours** |
|  | Core – XI - **ADVANCED TOPICS IN BIOINFORMATICS** | 5 | 6 |
| Core – XII - **TOOLS AND THEIR APPLICATIONS IN BIOINFORMATICS (PRACTICALS)** | 5 | 6 |
| Project with VIVA VOCE | 7 | 10 |
| Elective – VI - **SYSTEMS BIOLOGY: METHODS AND APPLICATIONS (OR) MICROARRAY TECHNOLOGIES AND ITS APPLICATIONS** | 3 | 4 |
| Skill Enhancement Course – III / Professional Competency Skill | 2 | 4 |
| Extension Activity | 1 | - |
|  |  | **23** | **30** |

* **Total 91 Credits for PG Courses**

**SEMESTER - I**

|  |  |
| --- | --- |
| **Core Course - I** | **Core I: MDP** |
| **Title of the Course:** | **STRUCTURE, SYNTHESIS, REGULATION & CELLULAR FUNCTIONS OF MACROMOLECULES** |
| **Credits:** |  **4** |
| **Pre-requisites, if any:** | Students should be familiar with the basics of Biomolecules and Molecular Biology |
| **Course Objectives:**1. To understand the basic structure and function of carbohydrates, lipid and nucleic acids.
2. To familiarize students with the various levels of organization of Proteins and its biological importance. Gain knowledge about the genetic code, molecular basis of protein synthesis & degradation
3. To comprehend the molecular basis of DNA and RNA synthesis, know the importance of the process, DNA damage and Repair.
 |
| **Course Outcomes:** |
| 1. Understand the Basic structure and functions of important biomolecules | K1 |
| 2. Gain knowledge on the process of DNA replication, RNA synthesis and translation processes at the eukaryotic levels. | K2 |
| 3. Understand the importance of the genetic material and the consequence of mutation. | K3 |
| 4. Understand the eukaryotic mechanism | K4 |
| 5. Comparing the prokaryotic and Eukaryotic process. | K5 & K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
| **Keywords:** Carbohydrates, Enzymes, Replication, Transcription. Operon, Genetic code**.** |
| **UNITS** |
| **UNIT I**Carbohydrates: Classification, structure and functions. Lipids - Structure and Functions. Protein – Primary, Secondary, tertiary and Quaternary structure of proteins, Ramachandran plot - Classification and Function of proteins. Nucleic acids: Structure of DNA, Types of DNA, Structural DNA polymorphism, RNA – types, secondary and tertiary structure of RNA. Functions of nucleic acids. |

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| **UNIT II**Enzymes: Classification of enzymes based on function, Factors affecting enzyme activity. Enzyme kinetics: Michaelis – Menten equation, LB plot, Determination of Km. |
| **UNIT III**Eukaryotic DNA replication machinery, Initiation, Elongation and Termination of DNA replication. Regulation of DNA replication, DNA Damage and Repair, Recombination, Mobile Genetic Elements (MGEs). |
| **UNIT IV**RNA Synthesis: Eukaryotic RNA transcription, Post transcriptional modifications of mRNA and rRNA. Tryptophan and Lac operon concepts. |
| **UNIT V**Protein Synthesis: The Genetic Code, Ribosome structure, Initiation, Elongation, Termination in eukaryotes, Inhibitors of translation, Post Translational Modifications, Protein Targeting, Protein degradation. |
| **Recommended Texts** |
| 1. Lewin's GENES XII, by Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick, Jones Bartlett Publishers, Inc; 12th edition, 2017.
2. Glick, BR; Pasternak, JJ (2003), “Molecular Biotechnology; Principles and Applications of Recombinant DNA”, 3rd edition, American Society of Microbiology.
3. Satyanarayan, U (2020) “Biotechnology”, 5th edition Books and Allied (Pvt) Ltd Calcutta.
 |
| **Reference Books**1. Jeremy M. Berg, John L. Tymozko, Lubert Styer (2002), “Biochemistry”, Fifth edition,W.H. Freeman and Company.1. Albert L. Lehninger, David L. Nelson, Michael M. Cox, Karen Ocorr (2005), “Principles of Biochemistry”, W H Freeman & Co,
2. Burton E. Tropp (2008), “Molecular Biology - Genes to Proteins”, Jones and Barlett’s Publishers.
3. Robert Weaver (2011), “Molecular Biology”, McGraw Hill.
4. George.M. Malacinski, “Essentials of Molecular Biology”, Fourth Edition-2015, Jones and Barlett’s Publishers.
5. James D. Watson, “Molecular Biology of the Gene”, Fifth Edition-2005, Cold Spring Habour Laborarory Press.
6. Harvey Lodish, Arnold Berk, S Lawrence Zipursky, Paul Matsudaira, David Baltimore, and James Darnell (2008), “Molecular Cell Biology”, 4th edition, W. H. Freeman.
7. Bruce Alberts (2008), “Molecular Biology of the Cell”: Reference Edition, Garland Science
 |
| **Reading List**1. https://bio.libretexts.org/Bookshelves/Introductory\_and\_General\_Biology/Book%3A\_Gen eral\_Biology\_(Boundless)
2. https:/[/www.biologydiscussion.com/or](http://www.biologydiscussion.com/organism/eukaryotes/translation-in-eukaryotes-)g[anism/eukaryotes/translation-in-eukaryotes-](http://www.biologydiscussion.com/organism/eukaryotes/translation-in-eukaryotes-) genetics/37991
3. https://microbenotes.com/transcription-vs-translation/
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**Mapping with Programme Outcomes and programme specific outcomes:**

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| **Cos** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | L | S | M | L | M | M | S | M |
| **CO 2** | S | S | M | M | S | S | M | S | S | S |
| **CO 3** | S | L | S | S | M | M | M | S | M | M |
| **CO 4** | S | S | S | S | S | M | S | S | S | S |
| **CO 5** | S | S | M | S | M | S | S | S | S | M |

**S-Strong M-Medium L-Low**

**Method of Evaluation**

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| **Internal Assessment** | **End semester exams** | **Total** |
| **Test 1**  | **Test 2** | **Other components (Seminars/quiz/assignments)** |
| 10 | 10 | 5 | 75 | 100 |

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| **Core Course - II** | **Core II: MDP** |
| **Title of the Course:** | **PRINCIPLES OF BIOTECHNOLOGY** |
| **Credits:** | **4** |
| **Pre-requisites, if any:** | Students should be familiar with the basics of Genetic Engineering, Genetically modified foods and Nanotechnology. |
| **Course Objectives:**1. To understand the basic concepts of genetic engineering and its applications, significance of vectors, as a tool in the construction of GMOs, bioethics and societal concerns about GMOs.
2. To gain basic understanding about the various blotting techniques, Antisense technology, hybridoma and DNA fingerprinting techniques.
3. To gain insight about Nanotechnology, nanoparticles and its applications in various fields.
 |
| **Course Outcomes:** |
| 1. Students gain knowledge about the genetic engineering process and its applications | K1 |
| 2. Students Gain insight about nanotechnology, Antisense technology, hybridoma and DNA fingerprinting techniques. | K2 |
| 3. Understanding of PCR, its modifications and current applications in various fields. | K3 |
| 4. Gain insight about Nanotechnology, nanoparticles and its applications in various fields | K4 |
| 5. Understanding bioethics and societal concerns about GMOs. | K5& K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
| **Keywords:** Genetic engineering**.** Plasmids, Phages, Cosmids, Gene Library, Hybridoma technology, Nanotechnology |
| **UNITS** |
| **UNIT I**Biotechnology: definition, scope, importance, genetic engineering and its applications. Expression systems, plasmids, cosmids, phages, viruses, YAC, BAC. |
| **UNIT II**Molecular probes, Gene library, restriction enzymes, RM system, SNP, RFLP, southern, western and northern blotting. |
| **UNIT III**Antisense RNA technology, DNA fingerprinting, Hybridoma technology, Basic PCR and its |

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| modifications, Applications of PCR in Molecular diagnosis. |
| **UNIT IV**Introduction to nanotechnology - Definition and scope of nanotechnology, Nanoparticle and Nano materials - structure and properties, Nanoscale. Types of Nanomaterials – metallic and nonmetallic, - Applications of Nano materials – Medicine, Agriculture, Environment & Health. Possibilities for the future, Pitfalls in nanotechnology. |
| **UNIT V**Biotechnology and bioethics: Issues from legal and ethical perspectives including property rights of transgenic and clones privacy discrimination - policy concerns to societal concerns in India and abroad. |
| **Recommended Texts**1. Benjamin Lewin (2004) “Genes VIII”, 12th edition, Pearson Education International.
2. Glick, BR; Pasternak, JJ (2003), “Molecular Biotechnology; Principles and Applications of Recombinant DNA”, 3rd edition, American Society of Microbiology
3. Satyanarayan, U (2020) “Biotechnology”, Books and Allied (Pvt) Ltd Calcutta.
4. Nanoscience and Nanotechnology: Fundamentals of Frontiers, Shubra Singh M.S. Ramachandra Rao, Wiley publishers, 2012.
5. Introduction to Nanoscience and Nanotechnology, Chattopadhyay K.K , Banerjee A,N, PHI learning private limited, 2009.
6. NANO: The Essentials: Understanding Nanoscience and Nanotechnology, T. Pradeep, McGraw Hill Education, 2017
 |
| **Reference Books**1. Watson J; Zoller M; Witowski J (1992) “Recombinant DNA” 2nd edition, W.H. Freeman
2. Old RW; Primrose SB; (1994) “Principles of gene manipulation-An introduction to genetic Engineering” 6th edition, Blackwell sciences.
3. Textbook of Nanoscience and Nanotechnology by T. Pradeep, McGraw Hill Education (India) Private Limited: 2017.
 |
| **Reading List**1. <http://www.biologydiscussion.com/essay/enzymes-essay/role-of-enzymes-> ingeneticengineering-essay-genetic-engineering/84627.
2. [http://biology.kenyon.edu/courses/biol114/Chap08/Chapter\_08a.html.](http://biology.kenyon.edu/courses/biol114/Chap08/Chapter_08a.html)
3. https://en.wikibooks.org/wiki/Nanotechnology/Introduction.
4. https://biology.kenyon.edu/courses/biol114/Chap08/Chapter\_08a.html#pcr.
5. https://biology.kenyon.edu/courses/biol114/Chap08/Chapter\_08a.html#Blots.
 |

**Mapping with Programme Outcomes:**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | L | S | M | L | M | M | S | M |
| **CO 2** | S | S | M | M | S | S | M | S | S | S |
| **CO 3** | S | M | S | S | L | M | L | S | M | L |
| **CO 4** | M | S | S | S | S | M | S | S | S | S |
| **CO 5** | S | S | M | S | M | S | S | S | S | S |

**S-Strong M-Medium L-Low**

**Method of Evaluation**

|  |  |  |
| --- | --- | --- |
| **Internal Assessment** | **End semester exams** | **Total** |
| **Test 1**  | **Test 2** | **Other components (Seminars/quiz/assignments)** |
| 10 | 10 | 5 | 75 | 100 |

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| --- | --- |
| **Core Course - III** | **Core III: MDP** |
| **Title of the Course:** | **PRINCIPLES OF COMPUTATIONAL BIOLOGY AND BIOLOGICAL DATABASES** |
| **Credits:** | **4** |
| **Pre-requisites, if any:** | Students should be familiar with the basics of computers, databases and algorithms. |
| **Course Objectives:**1. To become familiar with bioinformatics and how it’s changing complex biological research
2. To enable textual mining of biological literature and bioinformatics tools that are required to query biological data
3. To understand the application of information technology in biological research.
 |
| **Course Outcomes:** |
| 1. Better understanding of the bioinformatics concepts | K1 |
| 2. Emphasis the application of bioinformatics and biological databases | K2 |
| 3. Perform a complete analysis of the genes and protein | K3 |
| 4. Problem solving in real research problems | K4 |
| 5. Understand the evolutionary concepts related to biological query | K5& K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
| **Keywords:** Biological database, Algorithm, Alignment, PAM, BLOSUM,FASTA, BLAST |
| **UNITS** |
| **UNIT I**Biological Data Management -Biological Data Mining, Data Pre-processing and integration- Tools- Cluster Analysis Methods, Data Visualization. What is an Algorithm- Biological Algorithms – Recursive Algorithms– Fast & Slow Algorithms – Big O Notation – Algorithm Design Techniques – Exhaustive Search – Branch and Bound Algorithms – Greedy Algorithms – Dynamic Programming – Divide and Conquer Algorithms - Graph Algorithms - |
| String Matching- Machine Learning Algorithm- Randomized Algorithms. Longest Common Subsequences. |
| **UNIT II**Introduction to Nucleic Acid and Protein Sequence Data Banks- Nucleotide databases (Genbank, EMBL, DDBJ)- Protein databases (Swiss-Prot, Tr-EMBL, PIR\_PSD, Expasy) - Derived Databases (Prosite, PRODOM, Pfam, PRINTS)- Sequence submission Methods and tools (Sequin, Sakura, Bankit)- Sequence retrieval systems (Entrez & SRS) - Sequence File Formats and Conversion tools- Genome (NCBI, EBI, TIGR, SANGER)- Metabolic Pathwaydatabase (KEGG, EMP, EcoCyc, BioCyc and MetaCyc)- Specialized database (IMGT, Rebase, COG, LIGAND, BRENDA) - Structural database PDB. |

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| **UNIT III**The Power of DNA Sequence Comparison – Edit Distance and Alignments- Global Sequence Alignment – Needleman Wunsch Algorithm - Scoring Alignments -Detailed method of derivation of the PAM & BLOSUM Matrices – Local Sequence Alignment Smith Waterman Algorithms – Gap Penalties - Affine Gap Costs - Dynamic Programming for Multiple Sequence Alignment- Progressive Multiple Sequence Alignment with T-Coffee Method and Clustal Omega, Iterative MSA - Assessing the Significance of Sequence Alignments. Biobank, Data science using semantic analysis. |
| **UNIT IV**Regulatory Motifs in DNA Sequences – Profiles - The Motif Finding Problem – Search Trees– Finding Motifs – Genome Rearrangements – Sorting by Reversals - Dot Matrices – Shortest Superstring Problem - DNA Sequencing by Hybridization as a Hamiltonian & Eulerian Path Problem – Fragment Assembly in DNA Sequencing – The Peptide Sequencing Problem - Spectrum Graphs – Protein Identification via Database Search- Spectral Convolution –Spectral Alignment- Fold recognition - Lattice Models - Methods for Prediction of Secondary andTertiary structures of Proteins –Threading – Reverse Protein Folding. |
| **UNIT V**Combinatorial Pattern Matching – Repeat Finding – Hash Tables –Exact Pattern Matching – Suffix Trees – Heuristic Similarity Search Algorithms - Approximate Pattern Matching – BLAST – FASTA -Phylogenetic Tree Construction - Concept of Dendrograms; Evolutionary Trees - Distance Based Tree Reconstruction - Ultrametric trees and Ultrametric distances – Reconstructing Trees from Additive Matrices - Evolutionary Trees and Hierarchical Clustering- Character Based Tree Reconstruction – Maximum Parsimony Method, Maximum likelihood method - Reliability of Trees – Substitution matrices – Evolutionary models-JC, K2P, HKY,Invariant and gamma distribution Models. |
| **Recommended Texts**1. Jones, N. C., & Pevzner, P. A. (2004). An introduction to bioinformatics algorithms. MIT press.
2. Dan E. Krane and Michael L. Raymer, Fundamental Concepts of Bioinformatics, 2009, Dorling Kindersley India Pvt Ltd.
3. David W. Mount, Bioinformatics Sequence and Genome Analysis, Second Edition, 2004, Cold Spring Laboratory Press.
4. Jin Xiong, Essential Bioinformatics, 2006, Cambridge University Press.
 |
| 5. Jeremy J. Ramsden, Bioinformatics and Introduction, 2004, Kluwer Academic Publishers. |
| **Reference Books**1. Jason T.L Wang , Mohammed J.Zaki, Hannu T.T. Toivonen, Dennis Shasha, Data Mining in Bioinformatics, 2005, Springer Publications.
2. Hassan A. Sadek, Principles of Bioinformatics and Basic Internet Applications, 2004 Trafford Publications.
3. Pierre Baldi, Soren Brunak, Bioinformatics: The Machine Learning Approach, 2001, MIT Press
 |
| **Reading List**1. <http://bioinformaticsweb.net/tools.html>
2. https://[www.bits.vib.be/index.php/training/122-basic-bioinformatics](http://www.bits.vib.be/index.php/training/122-basic-bioinformatics)
3. <http://bioinformaticssoftwareandtools.co.in/>
4. <http://www.genscript.com/tools.html>
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**Mapping with Programme Outcomes:**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Cos** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | S | S | M | L | M | M | S | M |
| **CO 2** | M | S | L | M | S | S | M | S | S | S |
| **CO 3** | S | M | S | S | L | M | L | S | L | S |
| **CO 4** | S | S | S | S | S | M | S | S | S | M |
| **CO 5** | S | S | M | S | M | S | S | S | S | S |

**S-Strong M-Medium L-Low**

**Method of Evaluation**

|  |  |  |
| --- | --- | --- |
| **Internal Assessment** | **End semester exams** | **Total** |
| **Test 1**  | **Test 2** | **Other components (Seminars/quiz/assignments)** |
| 10 | 10 | 5 | 75 | 100 |

|  |  |
| --- | --- |
| **Core Course - IV** | **Core IV: MDP** |
| **Title of the Course:** | **APPLICATION OF PROGRAMMING FOR BIOLOGY-I (PRACTICALS)** |
| **Credits:** | **4** |
| **Pre-requisites, if any:** | Students should be familiar with the basics of languages like C++,UNIX and different file formats |
| **Course Objectives:**1. To facilitate the students in gaining programming skills.
2. To enable the students to design and execute C++ and Java and Unix scripts
3. To interpolate biological demands through programming
4. To be trained in designing databases and manipulating them for biological applications
 |
| 5. To understand the working knowledge of Linux environment |
| **Course Outcomes:**On successful completion of the course, the student will be able to |
| 1. Learn the basics of programming | K1 |
| 2. Relate the necessity for programming in biology | K2 |
| 3. Handling biological concepts with C++ and Java and Unix scripts | K3 |
| 4. Skills to Create, update, retrieve and Manage data, Handle files and databases | K4 |
| 5. Clear understanding and usage of SQL Language | K5 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
| **Keywords:** C++, Java, SQL, UNIX,LINUX |
| **UNITS** |
| **UNIT I C++**1. A program to sort the given numbers in ascending order using pointer
2. A Program to find the factorial of a given number using recursion
3. A Program to implement the polymorphism concepts with respect to bioinformatics details
4. A program to sort the given list of Amino acids
5. A program which demonstrates multiple inheritance
 |
| **UNIT II JAVA**1. A program to manipulate the string using character array and perform the following operations-Find a character at particular position or concatenate two strings
2. A Program to demonstrate multithread using class thread
3. A application program using JDBC Connectivity
4. A program that changes the color of the text each time when the key is pressed
5. A program to implement the mouse events using Applet
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| **UNIT III SQL**1. Create a SQL script file to easily copy a table from one database to another
2. A program of SQL Plus script to determine the product of values in a column
3. A SQL program to create a database which contains information of globlin
4. A SQL Script to delete, insert and modify contents in a specified rows in a table
5. A SQL script to joining multiple tables
 |
| **UNIT IV UNIX/LINUX**1. Create a unix file structure by using ftp
2. Create a unix file and copy its contents to create another file
3. A unix script to count the number of positively charged residues in a PDB file
 |
| **UNIT V**1. Create a Unix file structures and implementation in haemoglobin structures
2. Explain the following commands with example in linux terminal- lpr, ncftp, pwd, rsh, sort, tail, tar
 |
| **Recommended Texts** |
| 1. Hubbard, John (2000) “Programming with C++", Schaum’s outline series, Tata McGraw Hill International.
2. Thomas, Rebecca and Jean Yates (1987), “A user Guide to the UNIX system,” Tata McGraw Hill International.
3. Patrick Naughton and Herbertz Schildt (1999) “Java-2: The complete Reference”, Mcgraw- Hill Osborne Media.
 |
| **Reference Books**1. R. Lafore, Object Oriented Programming using C++. 2008, Pearson Eduction India.
2. Clark S. Lindsey, J. S. Tolliver, Thomas Lindblad. JavaTech: An Introduction to Scientific and Technical Computing with Java. 2005, Cambridge University Press.
3. Arnold Robbins & Daniel Gilly, (1999) “Unix in a Nutshell”, O’Rielly and Associates.
4. Kay. A Robbins, Steven Robbins, Kay. Ret. Robbins and Steve Robbins (1999) “The C programming language”, Prentice Hall.
5. Cox K., Red Hat Linux Administrators Guide, PHI (2001).
6. Stanley Letovsky, Bioinformatics: Databases and Systems, 2006, Springer.
7. Abraham, Silbers chatz, Henry F. Korth, Sudarshan S, Database system Concepts, McGraw Hill Education, 2013.
 |
| **Reading List**1. [www.oracle.com/technetwork/oem/db-mgmt/db-mgmt-093445.html](http://www.oracle.com/technetwork/oem/db-mgmt/db-mgmt-093445.html)
2. [http://education-portal.com/academy/lesson/what-is-a-database-management-](http://education-portal.com/academy/lesson/what-is-a-database-management-systempurpose-and-function) [systempurpose-and-function](http://education-portal.com/academy/lesson/what-is-a-database-management-systempurpose-and-function).
3. html [www.odbms.org/](http://www.odbms.org/)
4. <http://www.comptechdoc.org/os/linux/usersguide/linux_ugbasics.html> <http://www.dummies.com/how-to/content/common-linux-commands.html>
5. <http://www.cplusplus.com/doc/tutorial/>
6. <http://www.cprogramming.com/>
7. <http://www.stroustrup.com/4th.html>
 |

**Mapping with Programme Outcomes:**

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| **Cos** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | L | S | M | L | M | M | S | M |
| **CO 2** | S | S | M | M | S | S | M | S | S | S |
| **CO 3** | M | M | S | S | L | M | L | S | M | S |
| **CO 4** | S | S | S | S | S | M | S | S | S | S |
| **CO 5** | S | S | M | S | M | S | S | S | S | S |

**S-Strong M-Medium L-Low**

**Method of Evaluation**

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| --- | --- | --- |
| **Internal Assessment** | **End semester exams** | **Total** |
| **Test 1**  | **Test 2** | **Other components (Seminars/quiz/assignments)** |
| 10 | 10 | 5 | 75 | 100 |

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| **Elective Course - I** | **Elective -1: MDP** |
| **Title of the Course:** | **MATHEMATICAL & STATISTICAL METHODS FOR BIOLOGISTS** |
| **Credits:** | **3** |
| **Pre-requisites, if any:** | Students should be familiar with the basics |
| **Course Objectives:**1. Be able to write and understand basic proofs. To develop and maintain problem-solving skills. To use mathematical ideas to model real-world problems.
2. To introduce students to the application of mathematical modeling in the analysis of biological systems including populations of molecules, cells and organisms.
 |
| **Course Outcomes:** |
| 1. Students have an enhanced knowledge and understanding of mathematical modeling and statistical methods in the analysis of biological systems; | K1 & K2 |
| 2. Students assess biological inferences that rest on mathematical and statistical arguments; | K3 & K4 |
| 3. Students analyze data from experiments and draw sound conclusions about the underlying processes using their understanding of mathematics and statistics. | K35& K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
| **Keywords:** Geometry, Calculus, Statistics, spreadsheets, Probability, |
| **UNITS** |
| **UNIT I**2D Geometry – Equation of a Line, Circle, Ellipse, Parabola – 3D Geometry – Equation of Sphere, Cone - Trigonometric functions- Sin, Cos, Tan, Cot Series expansion of these functions and other related functions – Vectors Additions, Subtraction, Dot, Cross, Scalar Triple Product, Divergent - Curl of a Vector - Matrix Additions, Subtraction, Multiplication, Transpose, Inverse and Conjugate of Matrix. |
| **UNIT II**Calculus: Differentiation and Integration –Limits - Complete Differentials - Partial Differentials of functions with one variable and multiple variables- Definite and non-definite integral- Series, Logarithms- Ordinary Differential Equations (First Order) - Special Functions– Bessel, Legendre - Fourier Transforms – Laplace Transforms - Applications. |
| **UNIT III**Nature and scope of statistical methods and their limitations compilation, classification, tabulation and application in life sciences – Measures of central value, dispersion, coefficient of variation - Graphic representation frequency curve and its characteristics– Skewness, kurtosis, moments – Correlation and regression – Correlation table – Coefficient of correlation– Z transformation – Regression – Relation between regression and correlation. Probability – Markov chains applications – Probability distributions – Binomial (Gaussian distribution) and negative binomial, compound and multinomial distributions – Poisson distribution – Normal |

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| distribution. |
| **UNIT IV**Basis of Statistical Inference –Sampling Distribution – Standard Error – Testing of Hypothesis* Null Hypothesis –Type I and Type II errors - Tests of Significance for large and small samples based on Normal, t, z distributions with regard to mean, variance, proportions and correlation coefficient – chi-square test of goodness of fit – contingency tables – c2 test for independence of two attributes – Fisher and Behrens ‘d’ test – 2×2 table – testing heterogeneity
* r X c table – chi-square test in genetic experiments – partition X 2 – Emerson’s method – Tests of significance –t tests – F tests – Analysis of variance – one way classification – Two way classification, CRD, RBD, LSD.
 |
| **UNIT V**Spreadsheets – Data entry –Mathematical Functions – Statistical Function –Statistical analysis packages graphics/presentation packages- Introduction to R –Installing R – R Tutorials. DataFrames and Reading Data into R – Manipulating Data –Graphics with R – Reproducible Research. |
| **Recommended Texts**1. Zar, J.H. (1984), Bio Statistical Methods, Prentice Hall, International Edition.
2. Sundar Rao P. S.S., Jesudian G. & Richard J. (2012), An Introduction to Biostatistics, PHI Learning Private Limited.
3. Sharma AK (2005) Text Book of Integral Calculus, Discovery Publishing House.
4. Ramachary, SKVS; Bhaskar Rao, PB; Bhujanga Rao; M; Subramanyam PS (2005), Mathematical Methods, BS Publications.
5. Grewal, BS (2000), Higher Engineering Mathematics, 37th edition, Khanna Publishers, New Delhi
 |
| **Reference Books**1. Spiegel, Probability and Statistics (Schaum’s Outline Series), 2017, McGraw Hill Education.
2. S.C. Gupta & V.K. Kapur, 2014, Fundamentals of Mathematical Statistics, Sultan Chand & Sons.
3. Warren, J E; Gregory R Grant (2010), Statistical Methods in Bioinformatics, Springer
 |

**Mapping with Programme Outcomes:**

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| **Cos** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | S | S | M | L | M | M | S | S |
| **CO 2** | M | S | S | M | S | S | M | S | S | S |
| **CO 3** | S | M | S | S | L | M | S | S | M | S |
| **CO 4** | S | S | S | S | S | M | S | S | S | S |
| **CO 5** | S | S | M | S | M | S | S | S | S | S |

**S-Strong M-Medium L-Low**

**Method of Evaluation**

|  |  |  |
| --- | --- | --- |
| **Internal Assessment** | **End semester exams** | **Total** |
| **Test 1**  | **Test 2** | **Other components (Seminars/quiz/assignments)** |
| 10 | 10 | 5 | 75 | 100 |

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| **Elective Course - II** | **Elective -2: MDP** |
| **Title of the Course:** | **CELL BIOLOGY** |
| **Credits:** | **3** |
| **Pre-requisites, if any:** | Students should be familiar with the basics of biology, cellular components, cell division and cancer. |
| **Course Objectives:**1. To study the concept that the cell is the fundamental unit of life.
2. To understand the structure and purpose of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes and organelles.
3. To understand the communication between the cells
 |
| **Course Outcomes:** |
| 1. Understand the basics and insights of cell and its components | K1 & K2 |
| 2. Understand the structure, properties and functions of various cells and biological molecules | K3 & K4 |
| 3. Understand the pathways, interaction and regulation between the cells and the biological molecules | K35& K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
| **Keywords:** Cell theory, Nucleus, Mitochondria, Lysosomes, Golgi apparatus, Ribosomes, Peroxisome, Chloroplast, Chromosomes, Apoptosis |
| **UNITS** |
| **UNIT I**Cell theory, cell as the basic unit of life. Cell size, shape, comparison of prokaryotic and eukaryotic cell types including cellular specialization and differentiation, differences in plant and animal cells. |
| **UNIT II**Detailed description of eukaryotic cellular Organelles, Plasma membrane, rough and smooth Endoplasmic Reticulum, Nucleus, Mitochondria, Lysosomes, Golgi apparatus, Ribosomes, Peroxisome, Chloroplast and Glyoxisome. |
| **UNIT III**Biomembrane – structure, organization and basic functions, fluid mosaic model, Transport across cell membrane-uniport, symport and antiport. Passive and active transport and water channel. Animal structure of cytoskeleton- Composition and function of microfilament and intranuclear filament, Proton and Na+ –K+Pumps - examples and metabolic significance. |
| **UNIT IV**Chromosomes, types, structure and function. Cell division, mitosis, meiosis, their significance. Cell cycle –phase of cell cycle. |

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| **UNIT V**Apoptosis, Cancer - differences between benign and malignant tumors. Characteristics of cancer cells. Agents causing cancer- Physical, chemical, Biological. Cancer therapy – Surgery, radiation, chemotherapy. Cancer prevention. |
| **Recommended Texts**1. Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments (6th ed). John Wiley and Sons. Inc.
2. Bruce Alberts and Dennis Bray (2013), Essential cell biology, (4th ed), Garland science.
3. P.S. Verma and V.K Aggarwal. (2004) Cell Biology, Genetics, Molecular Biology, Evolution and Ecology, S. Chand and Company Ltd.
 |
| **Reference Books**1. Wayne M. Baker (2008) The World of the Cell. (7th ed). Pearson Benjamin Cummings Publishing, San Francisco. Cell Biology.
2. Cooper, G.M. and Hausman, R.E (2009). The Cell: A Molecular Approach. (5th ed). Sunderland, Mass. Sinauer Associates, Inc.
3. De Robertis, E.D.P and DeRobertis, E.M.F. (2010). Cell and Molecular Biology. (8th ed) Lippincott Williams and Wilkins, Philadelphia.
 |
| **Reading List**1. https://nicholls.edu/biol-ds/bio1155/Lectures/Cell%20Biology.pdf
2. https:/[/www.medic](http://www.medicalnewstoday.com/article/320878.php)a[lnewstoday.com/article/320878.php](http://www.medicalnewstoday.com/article/320878.php)
3. https://biologydictionary.net /cell
 |

**Mapping with Programme Outcomes:**

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| **Cos** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | L | S | M | L | M | M | S | M |
| **CO 2** | S | S | M | M | S | S | M | S | S | S |
| **CO 3** | M | M | S | S | L | M | L | S | M | S |
| **CO 4** | S | S | S | S | S | M | S | S | S | S |
| **CO 5** | S | S | M | S | M | S | S | S | S | S |

**S-Strong M-Medium L-Low**

**Method of Evaluation**

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| --- | --- | --- |
| **Internal Assessment** | **End semester exams** | **Total** |
| **Test 1**  | **Test 2** | **Other components (Seminars/quiz/assignments)** |
| 10 | 10 | 5 | 75 | 100 |

**SEMESTER – II**

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| **Core Course - V** | **Core V: MDP** |
| **Title of the Course:** | **BASIC PRINCIPLES OF CLINICAL TRIALS** |
| **Credits:** | **4** |
| **Pre-requisites, if any:** | Students should be familiar with the basics of human/clinical trials, guidelines to conduct trials and phases of trials. |
| **Course Objectives:**1. To understand basic clinical trials, WHO and ICMR guidelines to conduct clinical trials and to gain insight about the various clinical trial designs.
2. To understand the ICH – GCP guidelines required to conduct clinical trials.
3. To comprehend the responsibilities of key players involved in clinical trials and to gain knowledge about data management and documentation in the clinical trial process.
 |
| **Course Outcomes:**At the end of the course the student will be able to |
| 1. Explain the regulatory requirements for conducting clinical trial | K1 |
| 2. Describe in detail about various types of clinical trial designs | K2 |
| 3. Explain the responsibilities of key players involved in clinical trials | K3 |
| 4. Describe the documentational requirements for Clinical trials | K4 |
| 5. Explain Adverse drug reaction and its management | K5 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
| **Keywords:** Clinical trials, WHO, ICMR, ICH-GCP, CRP, C-COPS, CRA, Phases of clinical trials |
| **UNITS** |
| **UNIT I**Introduction to Clinical trials - History of clinical trials - Glossary of research terminology - Ethical Considerations: Developing Ethical Research Principles, regulations, guidelines: Nuremberg Code 1949, National Research Act 1974/81(DHHS 45CFR46), Declaration of Helsinki 1975, Belmont Report 1979, FDA (21CFR50/56) - Definitions of the Basic EthicalResearch Principles – WHO and ICMR requirements. |
| **UNIT II**Introduction to Basic design consideration – protocol requirements - Goals of clinical trials- Target population and patient selection - Selection of controls - Introduction to Randomization and blinding -Randomization Mode, Method and implementation - Assessing and Reporting adverse events - Safety Assessment - Good Clinical Practice Guidelines (GCP) and International Committee on Harmonization (ICH) - Guidelines - International versus US research guideline differences - Standard Operating Procedure guidelines |

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| **UNIT III**Defining the Research Team - Roles, Responsibilities, Organization Structure - Principal Investigator- Co Principal Investigator - Medical officer/writer – CRA - Research Pharmacist – Statistician Regulatory manager- Monitor/Auditor - Data manager- Contract Research Organizations, SMO’s, C-COPS - Funding entities - Institutional research organization/ Investigative sites, CRFs and eCRFs. Regulations and guidelines governing IRBs and IECs; Types of IRBs and IECs. Functions of IECs. |
| **UNIT IV**Phases of clinical trials: Phase 1, Phase 2, Phase 3 studies, Phase 4, Informed consent - Essential Items of Informed Consent, and Documentation; Process and Exceptions; Voluntary Consent of the subject; Insurance & Compensation to Subjects; Obligation of the sponsor to pay; Compensation for Participation; Vulnerable populations; Selection of special groups -Pregnant or nursing women, Children; Impartial Witness |
| **UNIT V**Investigational product manufacture, financial management, Audit, report writing. |
| **Recommended Texts**1. Shein-Chung Chow, Jen-Pei Liu (1992), Design and Analysis of Clinical Trials: Concepts and Methodologies.
2. Eleanor McFadden (2007), Management of Data in Clinical Trials, Frontier Science, Ltd.
3. Susanne Prokscha (2011) Practical Guide to Clinical Data Management.
4. Richard K. Bondel, Sheila A.Varley, Colin F.Webb, (2000), Clinical Data Management, Second Edition, Wiley Publications.
 |
| **Reference Books**1. Robinson (2008), Clinical Trial Project Management. Institute of Clinical Research.
2. John I. Gallin, Frederick P. Ognibene (2012), Principles and Practice of Clinical Research, Elsevier Publications.
3. Lawerence M. Friedman, Curt D.Furberg (2010), Fundamentals of Clinical Research, Springer Science.
 |
| **Reading List**1.https://database.ich.org/sites/default/files/ICH\_E6-R3\_GCP-principles\_Draft\_2021\_0419.pdf. 2.https:/[/www.youtube.com/watch?v=O3EwxEYM0t4.](http://www.youtube.com/watch?v=O3EwxEYM0t4)3.https:/[/www.brightfoc](http://www.brightfocus.org/clinical-trials/how-clinical-trials-work/phases-clinical-trials)u[s.org/clinical-trials/how-clinical-trials-work/phases-clinical-trials.](http://www.brightfocus.org/clinical-trials/how-clinical-trials-work/phases-clinical-trials) 4.https://en.wikipedia.org/wiki/Clinical\_study\_design.5.https:/[/www.youtube.com/watch?v=3\_93o8RuaMo.](http://www.youtube.com/watch?v=3_93o8RuaMo) |

**Mapping with Programme Outcomes:**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Cos** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | L | S | M | L | M | M | S | M |
| **CO 2** | S | S | M | M | S | S | M | S | S | S |
| **CO 3** | M | M | S | S | L | M | L | S | M | S |
| **CO 4** | S | S | S | S | S | M | S | S | S | S |
| **CO 5** | S | S | M | S | M | S | S | S | S | S |

**S-Strong M-Medium L-Low**

**Method of Evaluation**

|  |  |  |
| --- | --- | --- |
| **Internal Assessment** | **End semester exams** | **Total** |
| **Test 1**  | **Test 2** | **Other components (Seminars/quiz/assignments)** |
| 10 | 10 | 5 | 75 | 100 |

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| **Core Course - VI** | **Core VI: MDP** |
| **Title of the Course:** |  **GENOMICS AND PROTEOMICS** |
| **Credits:** | **4** |
| **Pre-requisites, if any:** | Students should be familiar with the basics of concept of omics, techniques involved in sequencing, mapping and genome projects. |
| **Course Objectives:**1. The objectives of this course are to provide introductory knowledge concerning genomics & proteomics and their applications.
2. To understand the concepts of latest techniques such as next generation sequencing.
3. To gain insight into Structural genomics, Mass spectrometry and its applications.
 |
| **Course Outcomes:**At the end of the course the student will be able to |
| 1. Acquire knowledge and understanding of the fundamentals of genomics and proteomics. | K1 |
| 2. Understand the latest techniques in NGS | K2 |
| 3. Gain the knowledge in metabolomics and the applications in various applied areas of biology | K3 |
| 4. Gain insight into Structural genomics, Mass spectrometry and its applications | K4 |
| 5. Gains knowledge concerning genomics & proteomics and their applications. | K5 & K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
| **Keywords:** Genome projects, Mapping, SAGE, GRAIL, Genscan |
| **UNITS** |
| **UNIT I**Organization of the Prokaryotic and Eukaryotic genomes – Genome Projects-Human Genome Projects- Plant Genome Projects- Microbial Genome Projects - Genome Databases- GOLD, TIGR,UCSC. |
| **UNIT II**Mapping methods – Physical Mapping & Genetic Linkage Mapping - Current Sequencing technologies – Shotgun Sequencing – Whole Genome Sequencing – Pyrosequencing - Partial sequencing – Next Generation Sequencing Technologies - Genome Fragment Assembly - Softwares for Sequencing and Assembly - Microarrays - SAGE - Gene identification – Gene Prediction Rules and Softwares- ORF -Finding – Hidden Markov Models – Neural Networks – Genscan – Exon Finder – GRAIL. |

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| **UNIT III**Gene density- Gene Ontology- Gene Order (synteny)- Plasticity zone - Gene Network - Gene Clusters- Segmental duplication - Non-coding conservation- Comparative genomics- Importance of Full Genome Alignments- Concepts & applications of Suffix tree in comparative genomics- Algorithms for BLAST2, MegaBlast- MUMmer . |
| **UNIT IV**Life cycle of a protein – Functional Protein Families - Extracting Proteins from Biological Samples – Protein Separation before and after digestion using PAGE - Preparative IEF, and HPLC – Tandem LC approaches for peptide analysis – Protein digestion technique –– Mass spectrometry protein – Software for Mass Spectrometry Data analysis. |
| **UNIT V**Protein stability and Folding-SCOP-DALI-Prediction of protein function- -– Protein Databases- Interactomics - Metabolic Network |
| **Recommended Texts**1. Primrose, S.B. and Twyman, R.M. (2003). “Principles of Genome Analysis and Genomics”: 3rd edition, Blackwell Publishing Company, Oxford, UK.
2. Liebler, D.C. (2002). “Introduction to Proteomics – Tools for the New Biology”, 1st Edition, Humana Press Inc., New Jersey, USA.
3. Orengo, C.A., Jones, D.T. and Thornton, J.M. (2003). “Bioinformatics – Genes, Proteins and Computers”, 1st Edition, BIOS Scientific Publishers Limited, Oxford, UK. .
 |
| **Reference Books**1. Mount, D.W. (2001). “Bioinformatics – Sequence and Genome Analysis”, 1st Edition, Cold Spring Harbor Laboratory Press, New York, USA.
2. Westhead, D.R., Parish, J.H. and Twyman, R.M. (2003). “Instant Notes Series – Bioinformatics”, 1st Edition, Viva Books Private Limited, New Delhi, India.
3. Ignacimuthu, S. (2005). “Basic Bioinformatics”, 1st Edition, Narosa Publishing House, New Delhi, India.
4. Lesk, A.M. (2002). “Introduction to Bioinformatics”, 1st Edition, Oxford University Press, Oxford, UK.
 |
| **Reading List**1. https:/[/www.dbt.univr.it](http://www.dbt.univr.it/documenti/OccorrenzaIns/matdid/matdid497258.pdf)/[documenti/OccorrenzaIns/matdid/matdid497258.pdf](http://www.dbt.univr.it/documenti/OccorrenzaIns/matdid/matdid497258.pdf)
2. https://bioinformatics.mdanderson.org/MicroarrayCourse/Lectures09/ngs1\_bw.pdf.
3. [http://www.premierbiosoft.com/tech\_notes/microarray.html.](http://www.premierbiosoft.com/tech_notes/microarray.html)
4. https:/[/www.onlinebiol](http://www.onlinebiologynotes.com/mass-spectrometry-principle-instrumentation-and-)o[gynotes.com/mass-spectrometry-principle-instrumentation-and-](http://www.onlinebiologynotes.com/mass-spectrometry-principle-instrumentation-and-) applications.
5. https://thebiologynotes.com/protein-databases-types-and-importance.
 |

**Mapping with Programme Outcomes:**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Cos** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | L | S | M | L | M | M | S | M |
| **CO 2** | S | S | M | M | S | S | M | S | S | S |
| **CO 3** | M | M | S | S | L | M | L | S | M | S |
| **CO 4** | S | S | S | S | S | M | S | S | S | S |
| **CO 5** | S | S | M | S | M | S | S | S | S | S |

**S-Strong M-Medium L-Low**

**Method of Evaluation**

|  |  |  |
| --- | --- | --- |
| **Internal Assessment** | **End semester exams** | **Total** |
| **Test 1**  | **Test 2** | **Other components (Seminars/quiz/assignments)** |
| 10 | 10 | 5 | 75 | 100 |

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| **Core Course - VII** | **Core VII: MDP** |
| **Title of the Course:** | **PRACTICALS RELATED TO PAPERS I & II** |
| **Credits:** | **4** |
| **Pre-requisites, if any:** | Students should be familiar with the basics of Biochemistry and Molecular biology |
| **Course Objectives:**1. To develop observational skills
2. To develop skills in biochemical and molecular biological techniques,
3. To demonstrate understanding of their theoretical basis
 |
| **Course Outcomes:** |
| 1. Students will demonstrate a core knowledge base in the theory and practice of Biochemistry and Molecular Biology | K1 |
| 2. Students will function successfully in the laboratory and use safe laboratory practices. | K2 |
| 3. Develop observational skills | K3 |
| 4. Demonstrate understanding of their theoretical basis | K4 |
| 5. Perform experiment design and analyze the results | K5 & K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
| **Keywords:** Buffers, Cell fractionation, Chromatographic techniques, Electrophoretic techniques, Immunological methods |
| **UNITS** |
| **UNIT I**Preparation of buffers, determination of pH, assay of protein by Lowry’s method and Bradford method, Assay of glucose by Orthotoluidine method, assay of DNA.Enzyme assay: Determination of specific activity of alkaline phosphatase, Effect of pH and |

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| substrate concentration on alkaline phosphatase activity |
| **UNIT II**Cell fractionation and Isolation of cell organelles- Disruption of cells - Isolation of subcellular organelles- Isolation of plasmid DNA - Genomic DNA |
| **UNIT III**Chromatographic Techniques - Gel Filtration- Ion Exchange – Affinity - Thin layer Chromatography. |
| **UNIT IV**Electrophoretic Techniques - Agarose Gel Electrophoresis - SDS PAGE - Molecular WeightDetermination of plasmid DNA and Protein - Western Blotting - Southern blotting. Amplification of DNA by PCR. |
| **UNIT V**Immunological Methods Based on Antigen-Antibody – Precipitation Reaction Based Assays, Agglutination Based Tests - Enzyme Linked Immunosorbent Assay (ELISA). |
| **Reference Books**1. Wilson, K; Walker, J (Editors) (2005) “Principles and techniques of Biochemistry and Molecular Biology”6th edition, CUP.
2. Sambrook, J; Russel, DW (2001) “Molecular Cloning”, 3rd edition, Cold Spring Harbor Laboratory Press,.
3. Sadasivam, S; Manickam, A (1996) “Biochemical Methods”, 2nd edition, New Age International Pvt Ltd
4. Introductory Practical Biochemistry, by S.K. Sawhney and R. Singh, Narosa Publishing House; 2001
5. Animal Cell Culture: Essential Methods, John M. Davis (Eds), WILEY-BLACKWELL; 2011
 |

**Mapping with Programme Outcomes:**

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| **Cos** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | L | S | M | L | M | M | S | M |
| **CO 2** | S | S | M | M | S | S | M | S | S | S |
| **CO 3** | M | M | S | S | L | M | L | S | M | S |
| **CO 4** | S | S | S | S | S | M | S | S | S | S |
| **CO 5** | S | S | M | S | M | S | S | S | S | S |

**S-Strong M-Medium L-Low**

**Method of Evaluation**

|  |  |  |
| --- | --- | --- |
| **Internal Assessment** | **End semester exams** | **Total** |
| **Test 1**  | **Test 2** | **Other components (Seminars/quiz/assignments)** |
| 10 | 10 | 5 | 75 | 100 |

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| **Core Course - VIII** | **Core VIII: MDP** |
| **Title of the Course:** | **APPLICATION OF PROGRAMMING FOR BIOLOGY– II** |
| **Credits:** | **4** |
| **Pre-requisites, if any:** | Students should be familiar with the basics of concept of programming in Biology. |
| **Course Objectives:**1. To facilitate the students in gaining programming skills.
2. To enable the students to design and execute HTML, Perl and SAS scripts
3. To interpolate biological demands through programming
4. Demonstrate how to locate and download files for data analysis involving genes and medicine Select datasets, open files and pre-process data using Python and R language
 |
| **Course Outcomes:**At the end of the course the student will be able to |
| 1. Relate the necessity for programming in biology | K1 |
| 2. Handling biological concepts with Python and R scripts | K2 |
| 3. Apply programming to analyse genomic sequences | K3 |
| 4. Gain efficient programming skills | K4 |
| 5. Perform genomic data analysis | K5 & K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
| **Keywords:** Genome projects, Mapping, SAGE, GRAIL, Genscan |
| **UNITS** |
| **UNIT I**Introduction to Perl 5- Variable and Data Types – Perl Variables – Scalar Values – Special Variables – Arrays – Arrays Manipulation – Push and Pop, Shift and Unshift – Splice – Useful Array Functions – List and Scalar Context – Hashes – Maintaining a Hash – Control Structures– Choices – If, Boolean Operators, If Else – Loops – Indeterminate Loops – Loop Exists . Intermediate Perl – Subroutines – Creating a Subroutine - Arguments – Return –Want array – Scope – Passing Arguments with References – Sort Subroutines – String Manipulation – Array Based Character Manipulation |
| **UNIT II**HTML-Structure tags-Tag Attributes-Linking to other web pages- Creating a static HTML files by a Perl Program- Creating a Web Page “on the fly” by a CGI – Program-Receiving CGI–Arguments from the URL - Using CGI Program for parsing the query string- Receiving CGI- Program arguments from a Web- PHP & Visual Basic: Introduction to PHP- Accessing Local Databases and Local programs using PHP - Visual Basic introduction, Front and Back End Connectivity using VB. |
| **UNIT III**Introduction to Python: Python basics – Scripting - Working with files – Object oriented Programming in Python - Command Line Arguments & Regular expressions – DataPreprocessing in Python- Numerical computing in Python - Accessing web data via Python. |

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| Biopython-Getting started and installation, Coding DNA, proteins, extracting translations - Modules- Bio Import, Bio Seq, Bio Align- Plot ABI traces, Retrieve and Annotate Entrez gene |
| **UNIT IV**Introduction to R language- R software – installation and use. How does R work? Basic fundamentals, Objects-Creating, listing, deleting the objects. Functions, Assignments and operators. Bioconductor -Introduction, Bioconductor Packages. Expression set, data annotation biomart - Applications of R in Phylogenetics and Sequence analysis |
| **UNIT V**Bio SAS Programming – Introduction – Syntax Rules – Types of Data File – Providing Data in the Program – Creating Variables – SAS Operators and Functions - Reading raw data - Combining Datasets – PROC SQL –Using Procedures to Generate Datasets – Libnames and SAS Datasets – Processing – Creating counters – Lags in Panel Datasets – Arrays – Writing ASCII Output Datasets –Creating or Reading CSV Files – Export and Import –PROCTranspose –PROC Expand –ODS to generate customized datasets from PROCS –IML Interactive Matrix Language – Macros. |
| **Recommended Texts**1. Perl Programming for Bioinformatics & Biologists, by D. Curtis Jamison, Wiley India Pvt Ltd; 2003
2. Python Programming Fundamentals, by Kent D. Lee, Springer, 2010.
3. Programming PHP, by Kevin Tatroe, O’Reilly publisher, 2006
4. PHP Programming with MySQL, by Don Gosselin, Robert Easterbrooks, Diana Kokoska, Course Technology Inc; 2010
5. Statistical Programming in SAS, by John Bailer, SAS Institute; 2015
 |
| **Reference Books**1. Doyle Paul, Micheal O Foghlu, David Harlan, Shelly Powers, Matthew D. Healy; (1996). “Using Perl for Web Programming”
2. James. D. Tosdall. (2000),“Beginning Perl for Bioinformatics” 1st edition, O’Rielly and Associates.
3. Larry Wall, Tom Christiansen, Jon Orwant (2000). “Programming Perl “3rd edition, O’Rielly and Associates
4. Randall. L. Schwartz & Tom Phoenix (2000). “Learning Perl “1st edition, O’Rielly and Associates
5. Scott Guelich, Shishir Gundavaram, Gunther Birzneits and Linda Mui,(2000),”CGI Programming”, 2nd edition, O’Rielly and Associates
6. Mark Lutz, (2009), Learning Python.
7. David M.Beazley (2009), Python Essential Reference.
8. Jack Shostak (2005), SAS Programming in the Pharmaceutical Industry.
9. Rick Aster (2010) Professional Sas Programming Secrets.
 |
| **Reading List**1. [www.sthurlow.com/python/](http://www.sthurlow.com/python/)
2. [www.learnpython.org](http://www.learnpython.org/)
3. [www.codecademy.com/en/tracks/python](http://www.codecademy.com/en/tracks/python)
4. https://docs.python.org/2/tutorial/
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**Mapping with Programme Outcomes:**

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| **Cos** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | L | S | M | L | M | M | S | M |
| **CO 2** | S | S | M | M | S | S | M | S | S | S |
| **CO 3** | M | M | S | S | L | M | L | S | M | S |
| **CO 4** | S | S | S | S | S | M | S | S | S | S |
| **CO 5** | S | S | M | S | M | S | S | S | S | S |

**S-Strong M-Medium L-Low**

**Method of Evaluation**

|  |  |  |
| --- | --- | --- |
| **Internal Assessment** | **End semester exams** | **Total** |
| **Test 1**  | **Test 2** | **Other components (Seminars/quiz/assignments)** |
| 10 | 10 | 5 | 75 | 100 |

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| **Elective Course – III** | **Elective III-MDP** |
| **Title of the Course:** |  **PHARMACOGENOMICS** |
| **Credits:** | **3** |
| **Pre-requisites, if any:** | Students should be familiar with the basics of pharmacogenomics |
| **Course Objectives:**1. To outline how genetic variability in genes can contribute to variability in drug disposition and action, leading to changes in pharmacokinetics, pharmacodynamics, and clinical outcome.
2. To understand the impact of Pharmacogenomics in different therapeutic areas.
3. To explain the genetic basis of variability in drug response
 |
| **Course Outcomes:** |
| 1. Understanding of the principles of human genetics and genomics | Ki |
| 2. Apply to improving the problems in drug therapy optimization and patient care. | K2 |
| 3. Providing basic understanding of the discipline of pharmacogenomics. | K3 |
| 4. Understanding the genetic basis of variability in drug response. | K4 |
| 5. Evaluate the drug efficacy and toxicity, adverse drug reactions and drug-d interaction | K5 & K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
| **Keywords:** Pharmacogenomics, Drug action, drug toxicity. |
| **UNITS** |
| **UNIT I**Pharmacogenomics - Principles -Pharmacodynamics- Pharmacokinetics- Personalized Medicine – Promises - Scope – Limitations - The Human Genome - Pharmacogenomics and Translational Approaches. |
| **UNIT II**Factors that Contribute Variability in Drug Response – Inter individual Genetic Variation – Turning SNPs into Useful Markers of Drug Response –Structural Pharmacogenomics- Association Studies – Genomics Applications that facilitate the understanding of Drug Action and Toxicity – Genes Involved in Drug Metabolism. |
| **UNIT III**Functional Analysis of Gene Variation – Transfection Assays with Allele Specific Constructs – Genome wide Analysis of Allele Specific Variation Using Oligo Microarrays –HaploChIP- Genotyping Techniques – Denaturing HPLC - Pyrosequencing –Taqman Sequencing –Kinetic Fluorescence Quenching –Mass Spectrometry –SNP Genotyping –Pharmacogenetics Testing in the Laboratory – Selection – Regulation –Interpretive Reports. |

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| **UNIT IV**Pharmacogenomics of Cancer - Warfarin Therapy - Anesthesia and Pain Management – Immunosuppressant – Cardiovascular Drugs – Antiretroviral Therapy –Psycho Active Drugs – Adverse Drug – Drug Interactions |
| **UNIT V**Pharmacogenomics Knowledge Base – Genotype – Molecular – Clinical Data –Genes – Drugs– Diseases – Pathways –Systems for the Management of Pharmacogenomic information. |
| **Recommended Texts**1. Federico Innocenti (2012), Pharmacogenomics Protocols and Methods, Springer.
2. Chiranjib Chakraborty, Atanu Bhattacharyya (2013) Pharmacogenomics: an approach to new drug development, Biotech.
 |
| **Reference Books**1. Loralie J. Langman, Amitava Dasgupta (2009), Pharmacogenomics in Clinical Therapeutics, Wiley-Blackwell.
2. Martin M. Zdanowicz (2010), Concepts in Pharmacogenomics, American Society of Health-System Pharmacists.
 |
| **Reading List**1. https://ascpt.onlinelibrary.wiley.com/doi/abs/10.1038/clpt.2012.96
2. https://pubmed.ncbi.nlm.nih.gov/19479657/
3. https://pubmed.ncbi.nlm.nih.gov/32580376/
4. https://pubmed.ncbi.nlm.nih.gov/22992668/
5. https://pubmed.ncbi.nlm.nih.gov/34232575/
 |

**Mapping with Programme Outcomes:**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Cos** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | L | S | M | L | M | M | S | M |
| **CO 2** | S | S | M | M | S | S | M | S | S | S |
| **CO 3** | M | M | S | S | L | M | L | S | M | S |
| **CO 4** | S | S | S | S | S | M | S | S | S | S |
| **CO 5** | S | S | M | S | M | S | S | S | S | S |

**S-Strong M-Medium L-Low**

**Method of Evaluation**

|  |  |  |
| --- | --- | --- |
| **Internal Assessment** | **End semester exams** | **Total** |
| **Test 1**  | **Test 2** | **Other components (Seminars/quiz/assignments)** |
| 10 | 10 | 5 | 75 | 100 |

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| **Skill enhancement Course – I** | **Extra Disciplinary I-MDP** |
| **Title of the Course:** | **BIOINFORMATICS AND DRUG DESIGN** |
| **Credits:** | **2** |
| **Pre-requisites, if any:** | Students should be familiar with the basics drug design |
| **Course Objectives:**1. To provide clear concepts on drug discovery, various drug design types and process, drug development
2. To provide a theoretical background to the various methods of molecular modeling, mechanics and interaction
3. To develop and understand the mechanism of drug design using computers
 |
| **Course Outcomes:** |
| 1. Understand the importance of drug-like properties and their prediction | K1 |
| 2. Describe the use of lead candidates and database representations | K2 |
| 3. Understand Molecular modeling and molecular dynamics methods to st structure from sequence | K3 |
| 4. Create and understand the mechanism of drug design using computers | K4 |
| 5. Evaluate the methods of molecular modeling, mechanics and interaction | K5 & K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
| **Keywords:** Bond angle, molecular modeling, docking. |
| **UNITS** |
| **UNIT I**Drug Discovery: Introduction- Conventional drug design approaches-Rational, various steps of drug design process-Structure based Drug Design- Ligand Based Drug Design. |
| **UNIT II**Genome to drug discovery – Structure properties & computer identification of eukaryotic genes – Analyzing regulatory regions in genomes- Subtractive Genomics - Vaccine development-Reverse Vaccinology. |
| **UNIT III**LBDD - Ligand based drug design- Quantitative structure activity relationship: QSAR, concept, and properties of organic molecules- Various descriptors used in the QSAR, multiple linear regression and its applications to drug design - Basics of combinatorial chemistry& natural product libraries – Chemical parameters in Drug design prodrugs & soft drugs – DrugRepurposing – ADME and Toxicity Assessment. |

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| **UNIT IV**Target discovery – Target validation – Assay development – High throughput screening – Lead optimization – Virtual high throughput screening - Drug substrate manufacture – Development of new drugs. De Novo Drug Design –CADD- Molecular modeling-Protein-ligand docking in drug design- Candidate drug nomination – Clinical Trials – Investigational new drug application – FDA, MDA, Approval, Patenting and Formulations –Marketing. |
| **UNIT V**Introduction to Next-generation sequencing- Introduction to Linux commands and DifferentPlatforms and Applications- Different file formats – FASTQ, SAM, BAM, GFF, Databases and tools – UCSC genome, Galaxy, SRA, NCBI refseq, ENA, FastQC, Bowtie.. |
| **Recommended Texts**1. Molecular Modeling: Principles and Applications, by Andrew Leach, Pearson publishers; 2001
2. Practical Application of Computer-Aided Drug Design, by Paul S. Charifson, CRC Press; 1997
 |
| **Reference Books**1. Richard B. Silverman, (2014), Organic chemistry of Drug Design & Drug action Elsevier Science, Academic Press.
2. Wu-Pong Susanna, Rojanasakul, Youngyut (1999) Biopharmaceutical Drug Design and
 |
| Development, Totowa, Humana Press.1. Andrew Leach (2001) Molecular modeling – Principles and Applications, Pearson.
2. Thomas Lengauer, Raimund Mannhold, H.Kubinyi, (Editors) Bioinformatics – From Genomes to Drugs – Methods & Principles in Medicinal Chemistry Vol-14, Wiley VCH.
3. H. Gerhard vogel, Wolgang H, (2002) Drug Discovery & Evaluation: Pharmacological assays. Springer.
4. Eric M.Gordon; James F.Kerwin (Editors) (1998) Combinatorial chemistry & Molecular Diversity in drug discovery, Wiley-Liss.
5. Stuart M.Brown (2002) Essentials of Medical Genomics, John Wiley & Sons.
 |
| **Reading List**1. [http://accessengineeringlibrary.com/browse/computer-aided-drug-design-and-delivery](http://accessengineeringlibrary.com/browse/computer-aided-drug-design-and-delivery%20systems) [systems](http://accessengineeringlibrary.com/browse/computer-aided-drug-design-and-delivery%20systems)
2. [http://www.southernresearch.org/life-sciences/lead-discovery-](http://www.southernresearch.org/life-sciences/lead-discovery-andoptimization/medicinalchemistry/computational-chemistry) [andoptimization/medicinalchemistry/computational-chemistry](http://www.southernresearch.org/life-sciences/lead-discovery-andoptimization/medicinalchemistry/computational-chemistry)
3. <http://www.ch.ic.ac.uk/local/organic/mod/>
4. <http://www.chemcomp.com/MOE-Molecular_Modeling_and_Simulations.html>
 |

**Mapping with Programme Outcomes:**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | L | S | M | L | M | M | S | M |
| **CO 2** | S | S | M | M | S | S | M | S | S | S |
| **CO 3** | M | M | S | S | L | M | L | S | M | S |
| **CO 4** | S | S | S | S | S | M | S | S | S | S |
| **CO 5** | S | S | M | S | M | S | S | S | S | S |

**S-Strong M-Medium L-Low**

**Method of Evaluation**

|  |  |  |
| --- | --- | --- |
| **Internal Assessment** | **End semester exams** | **Total** |
| **Test 1**  | **Test 2** | **Other components (Seminars/quiz/assignments)** |
| 10 | 10 | 5 | 75 | 100 |

**SEMESTER - III**

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| **Core Course – IX** |  **Core IX-MDP** |
| **Title of the Course:** | **MOLECULAR MODELING, METHODS AND APPLICATIONS** |
| **Credits:** | **4** |
| **Pre-requisites, if any:** | Students should be familiar with the basics of molecular modeling |
| **Course Objectives:**1. To provide a clear concept on bond angle, bond stretching, bond distance and role on different types of bonds in interaction.
2. To provide a theoretical background to the various methods of molecular modeling, mechanics and interaction.
3. To gain insights on protein-ligand docking and knowledge-based scoring functions.
 |
| **Course Outcomes:** |
| 1. Gain insight on the molecular dynamics and Monte Carlo simulation methods. | K1 |
| 2. Understand energy simulation methods and its importance in drug action. | K2 |
| 3. On successful completion of the course, the student will be able to perform protein structure prediction | K3 |
| 4. Apply molecular modeling and molecular dynamics methods to study structure from sequence. | K4 |
| 5. Gain insights on protein-ligand docking and knowledge-based scoring functions | K5 & K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
| **Keywords:** Bond angle, molecular modeling, docking. |
| **UNITS** |
| **UNIT I**Techniques used to determine the structure of biomolecules - Structure determination by X-ray crystallography, NMR spectroscopy, and Cryo-electron microscopy - Computational Structure prediction – Secondary structure – Homology modeling- Fold recognition and ab initio 3D structure prediction – Structure comparison and alignment – Prediction of function fromstructure. Geometrical parameters – Potential energy surfaces – Hardware and Software requirements- Molecular graphics – Molecular file formats- Molecular visualization tools. |
| **UNIT II**Molecular Docking- Flexible - Rigid docking- Target- Ligand preparation- Solvent accessibility- Surface volume calculation, Active site prediction- Docking algorithms- Genetic, Lamarckian - Docking analyses- Molecular interactions, bonded and non-bonded - MolecularDocking Software and Working Methods |

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| **UNIT III**Classical and Quantum mechanics: Elementary introduction to Lagrangian and Hamiltonian formulation of mechanics – Breakdown of Classical Mechanics – Planck theory of Blackbody radiation – Photoelectric effect – Bohr model of the atom – Atomic spectra – De Broglie theory of matter waves – Schrodinger wave equation – Interpretation of wave function – Atomic orbitals – Molecular orbitals – Hybrid orbitals –Valency of carbon atom – Covalent bond – Bond order – Resonance structure of Benzene – Partial double bond character of peptide bond |
| **UNIT IV**Molecular mechanics and dynamics: Basic principles – Molecular representations – Force fields – Atom-atom pair potentials – Bond length and bond angle and torsion angle potential – Van der Waals and Electrostatic potential – Hydrogen bonding terms – MM3, AMBER, GROMOS, CHARMM, ECEPP/3 force fields – Minimization techniques – Line search and elementary introduction to gradient techniques – Concepts of molecular dynamics – Introduction to time-Step integration algorithms – Dynamics protocols – Equilibration andData collection – Trajectories and their analyses – Graphical representations of trajectories of geometrical parameters. |
| **UNIT V**Molecular dynamics using simple models – Simulations with continuous potentials – Advantage of constant temperature and pressure simulation – Solvent effects – Analysis ofconformational changes during molecular dynamic simulation. |
| **Recommended Texts**1. Vasantha Pattabhi and N. Gautham (2001) ‘Biophysics’, Narosa Publishing Company, New Delhi
2. P. Narayanan (1999) ‘Introductory Biophysics’ New Age Publishing Co., Mumbai, India
3. D. Freifelder (1982) ‘Physical Biochemistry’ W.H. Freeman and Company, New York, USA.
 |
| **Reference Books**1. C.R.Cantor and P.Schimmel (1985) ‘Biophysical Chemistry, Vol. I, II and III’ W.H.Freeman and Company, New York, USA.
2. E.Ackerman, L.B.M.Ellis and L.E.Williams (1979) ‘Biophysical Science’ Prentice Hall Inc., New Jersey, USA
3. F.W.Sears, M.W.Zemansky and H.D.Young (1985). ‘College Physics’ Addison Wesley Publishing Company, Massachusetts, USA
4. C.N.Banwell (1983) ‘Fundamentals of Molecular Spectroscopy’ Tata McGraw-Hill Publishing Company Lt., New Delhi, India
5. D.Sherwood and Jon Cooper (2010) ‘Crystals, X-rays and Proteins: Comprehensive Protein Crystallography’ Oxford University Press.
6. A.R.Leach (1996) ‘Molecular Dynamics Simulation’ John Wiley and Sons, New York, USA
7. J.M.Haile (1992) ‘Molecular Dynamics Simulation’ John Wiley and Sons, New York, USA
8. C.Branden and J.Tooze (1991) ‘Introduction to Protein Structure’ Garland Publishing Company, New York, USA
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| **Reading List**1. [http://accessengineeringlibrary.com/browse/computer-aided-drug-design-and-delivery](http://accessengineeringlibrary.com/browse/computer-aided-drug-design-and-delivery%20systems) [systems](http://accessengineeringlibrary.com/browse/computer-aided-drug-design-and-delivery%20systems)
2. [http://www.southernresearch.org/life-sciences/lead-discovery-andoptimization](http://www.southernresearch.org/life-sciences/lead-discovery-andoptimization/medicinalchemistry/computational-chemistry)

[/medicinalchemistry/computational-chemistry](http://www.southernresearch.org/life-sciences/lead-discovery-andoptimization/medicinalchemistry/computational-chemistry)1. <http://www.ch.ic.ac.uk/local/organic/mod/>
2. <http://www.chemcomp.com/MOE-Molecular_Modeling_and_Simulations.html>
 |

**Mapping with Programme Outcomes:**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | L | S | M | L | M | M | S | M |
| **CO 2** | S | S | M | M | S | S | M | S | S | S |
| **CO 3** | M | M | S | S | L | M | L | S | M | S |
| **CO 4** | S | S | S | S | S | M | S | S | S | S |
| **CO 5** | S | S | M | S | M | S | S | S | S | S |

**S-Strong M-Medium L-Low**

**Method of Evaluation**

|  |  |  |
| --- | --- | --- |
| **Internal Assessment** | **End semester exams** | **Total** |
| **Test 1**  | **Test 2** | **Other components (Seminars/quiz/assignments)** |
| 10 | 10 | 5 | 75 | 100 |

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| **Core Course - X** | **Core X-MDP** |
| **Title of the Course:** | **CHEMINFORMATICS** |
| **Credits:** | **4** |
| **Pre-requisites, if any:** | Students should be familiar with the basics of Cheminformatics. |
| **Course Objectives:**1. To introduce the basic concepts of using chemical structure databases
2. To apply the concepts and learn the use of Cheminformatics tools
3. To understand the applications of Cheminformatics in drug design
 |
| **Course Outcomes:** |
| 1. Understanding of fundamentals of cheminformatics and its applications | K1 |
| 2. Understands the concepts in cheminformatics, | K2 |
| 3. Student is expected to achieve a good grasp of the concepts and applications of cheminformatics. | K3 |
| 4. Analyze the areas of Interface of chemistry, informatics and biology. | K4 |
| 5. Apply the concepts and learn the use of Cheminformatics tools | K5 & K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
| **Keywords:** Chemical database, Descriptors, QSAR, ADMET properties, Data source |
| **UNITS** |
| **UNIT I**Cheminformatics – Definition –History and Evolution– Databases: Chemical Structure Databases (PubChem, Binding database, Drug bank)–Molecular modeling –Structure Elucidation. |
| **UNIT II** |
| Representation of Chemical Compounds –Line Notations –Wiswesser Line Notation – ROSDAL –– The SMILES Coding –Sybyl Line Notations – SDF, MOL Files – 3D Structures Generation (PDB, STAR, CIF, mmCIF) - Models –Ball Sticks, Wireframe, Capped Sticks, Space Filling, Cylinder, Ribbon. Representation of Chemical Reactions – Chemical Reactivity- Resonance – Polarizability – Steric – Molecular Orbital–Stereochemistry |
| **UNIT III**Databases and Data Sources –DAT files – JCAMP- DX –PMML – Genetic Algorithm Based Solutions – Simulated Annealing Based Solutions –Preparation of Data sets for Validation of the Model Quality – Training and Data Sets Methods for Data Analysis – Neural Networks – Fuzzy Logic – Genetic Operators – Data Mining – Clustering – Structure Databases – Reaction Databases – Meta Databases. |
| **UNIT IV**Calculation of Structure Descriptors – Classification –Structure Keys and Finger Prints – Topological descriptors – The Wiener Index – 3D Descriptors – 3D Autocorrelation -3D MoRSE Code-Conformation Dependent and Independent Chirality Codes –Preparatory Calculations –Comparative Molecular Field Analysis – 4 D QSAR – HYBOT Descriptors – Structure Descriptors – Applications – Prediction of Properties of Compounds – Linear FreeEnergy Relationships – Quantity Structure Property Relationships. |

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| **UNIT V**Applications of Cheminformatics Tools - Definition of drugs, QSAR Pharmacophore Design, Fragment-Based Drug Design, ADMET Prediction -Design of Combinatorial Libraries. |
| **Reference Books**1. Johann Gasteiger and Thomas Engel (2003), Chemoinformatics: A Text Book, Wiley VCH
2. Andrew R. Leach, Valerie J.Gillet (2007), an introduction to Chemoinformatics, Springer.
3. Jurgen Bajorath (2004) Chemoinformatics Concepts and Methods, Humana Press.
4. R.Mannhold, H.Kubiniyi, G.Folkers (2005), Chemoinformatics in Drug Discovery, Wiley VCH.
5. Alexander Varnek, Alex Tropsha, (2008) Chemoinformatics approaches to Virtual Screening, Royal Society of Chemistry.
 |
| **Reading List**1. <https://onlinelibrary.wiley.com/doi/10.1002/3527601643.ch2>
2. <https://www.researchgate.net/publication/46279984_Cheminformatics>
3. [https://chem.libretexts.org/Courses/Intercollegiate\_Courses/Cheminformatics\_OLCC\_(2](https://chem.libretexts.org/Courses/Intercollegiate_Courses/Cheminformatics_OLCC_%282019%29/5._Quantitative_Structure_Property_Relationships/5.3%3A_Molecular_Descriptors) [019)/5.\_Quantitative\_Structure\_Property\_Relationships/5.3%3A\_Molecular\_Descriptors](https://chem.libretexts.org/Courses/Intercollegiate_Courses/Cheminformatics_OLCC_%282019%29/5._Quantitative_Structure_Property_Relationships/5.3%3A_Molecular_Descriptors)
4. <https://onlinelibrary.wiley.com/doi/abs/10.1002/3527601643.ch8>
 |

**Mapping with Programme Outcomes:**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | L | S | M | S | M | M | S | M |
| **CO 2** | S | S | M | M | S | S | M | S | S | S |
| **CO 3** | S | M | S | S | L | M | L | S | M | S |
| **CO 4** | S | S | S | S | S | M | S | S | S | S |
| **CO 5** | S | S | M | S | M | S | S | S | S | S |

**S-Strong M-Medium L-Low**

**Method of Evaluation**

|  |  |  |
| --- | --- | --- |
| **Internal Assessment** | **End semester exams** | **Total** |
| **Test 1**  | **Test 2** | **Other components (Seminars/quiz/assignments)** |
| 10 | 10 | 5 | 75 | 100 |

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| **Core Course – XI** | **Core XI-MDP** |
| **Title of the Course:** | **DATA MANAGEMENT AND REGULATORY REQUIREMENTS OF CLINICAL TRIAL** |
| **Credits:** | **4** |
| **Pre-requisites, if any:** | Students should be familiar with the basics of management of clinical trials |
| **Course Objectives:**1. To learn about various important acts, rules and regulatory authorities related to clinical trial process.
2. To study U.S. FDA regulatory compliance, GCP and GLP.
3. To learn Ethical and safety considerations, OECD guidelines in animal toxicity experiments, Data management and Monitoring in clinical trial.
 |
| **Course Outcomes:** |
| 1. Students will gain knowledge about various regulatory bodies governing clinical trials, GCP and GLP guidelines. | K1 |
| 2. Investigate new drug process and handling of clinical trial data | K2 |
| 3. Understand Ethical and safety considerations | K3 |
| 4. Evaluate animal toxicity procedures | K4 |
| 5. Applying guidelines in animal studies | K5 & K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
| **Keywords:** CDSCO, GLP, NDA & INDA, Toxicology, Patient registry |
| **UNITS** |
| **UNIT I**The Drugs and Cosmetics Act – 1940; Drugs and Cosmetics Rules – 1945; SCHEDULE Y, Amended Schedule Y of 2005; Regulatory Authorities – CDSCO, State Authorities, GEAC, HMSC; GCP as per Indian laws; Purpose of GCP; Evolution of Indian GCP; Ethical Principles of Indian GCP. Pathway to Clinical Trials in India; Drugs Controller General of India (DCGI); Institutional Committees (IC); IND (Investigational New Drug). |
| **UNIT II**Regulatory Toxicology Testing Good Laboratory Practice (GLP) – Introduction & Background of GLP – FDA GLP Inspection – Warning Letters & 483 - National GLP Monitoring Authority. |

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| **UNIT III**Non-clinical Safety Testing of Pharmaceuticals Laboratory Animals and In-vitro Test Systems in Regulatory Toxicology -Use of Animals in Toxicology Testing – Common Species in Toxicology Testing – *In vitro* Systems in Toxicology Testing . Timing of Toxicology Studies– Studies for NDA and ANDA – Rodent and non-rodent studies - Acute and Multi-dose Testing – Genetic Toxicology – Carcinogenicity – Developmental and Reproductive Toxicology – Neurotoxicology - Safety Pharmacology - Basic Principles of Safety Pharmacology - Assessment of Major Organ Functions – Report Preparation – Dose Extrapolation to FIH trials. |
| **UNIT IV**Introduction to Data Management - Biostatistics and meta-analysis – Clinical Trial Study Design - Planning – Data Definition – Management of Forms – Database Design - Computer Systems for Data Management and Monitoring Committee, DSMB – Computer validation and data entry , Data Analysis, Reporting, SAE reconciliation, Patient Registry, Software Toolsfor Trials Management. |
| **UNIT V**Safety Reporting - Indian Scenario & International Scenario; New drug application (NDA); Abbreviated New Drug Application (ANDA). Special Concerns in Indian Clinical Trial Regulations - Clinical Trials of Vaccines; Clinical trials with surgical procedures/medical devices; Clinical trials for Diagnostic Agents - Use of Radio-active Materials and X- Rays; Clinical trials of Herbal Remedies and Medicinal Plants. |
| **Reference Books**1. Jacobson-Kram, D. and Keller, K.A. (2006). Toxicological Testing Handbook – Principles, Applications and Data Interpretation, II Edition, Informa Healthcare, Newyork, pp 499
2. Stephen B.Hulley, Steven R. Cummings et al. (2011), Designing Clinical Research, Lippincott Williams & Wilkins.
3. Phillip I. Good (2006), A Manager’s Guide to the Design and Conduct of Clinical Trials, Wiley-Less.
4. Robert J. Levine (2011), Ethics and Regulations of Clinical Research, Yale University Press.
5. Richard Chin, Menghis Bairu (2011), Global Clinical Trials:Effective Implementation and Management, Academic Press.
6. Salah M.Abdel -Aleem (2011), The Design and Management of Medical Device
 |
| Clinical Trials, John Wiley Sons. |
| **Reading List**1. https://legislative.gov.in/sites/default/files/A1940-23.pdf.
2. https://learn.marsdd.com/article/clinical-trials-and-good-clinical-practice-gcp/.
3. https://vivotesting.com/what\_is\_the\_difference\_between\_GLP\_and\_GMP\_lab\_testing\_r egulations
4. https:/[/www.slideshar](http://www.slideshare.net/AKANKSHA241984/animal-toxicity-study-requirements-)e[.net/AKANKSHA241984/animal-toxicity-study-requirements-](http://www.slideshare.net/AKANKSHA241984/animal-toxicity-study-requirements-) for-conduct-of-clinical-trial-april-13-2019.
5. [https://www.youtube.com/watch?v=recRqCr\_uAI&t=453s.](https://www.youtube.com/watch?v=recRqCr_uAI&t=453s)
 |

**Mapping with Programme Outcomes:**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Cos** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | L | S | M | L | M | M | S | M |
| **CO 2** | S | S | M | M | S | S | M | S | S | S |
| **CO 3** | M | M | S | S | L | M | L | S | M | S |
| **CO 4** | S | S | S | S | S | M | S | S | S | S |
| **CO 5** | S | S | M | S | M | S | S | S | S | S |

**S-Strong M-Medium L-Low**

**Method of Evaluation**

|  |  |  |
| --- | --- | --- |
| **Internal Assessment** | **End semester exams** | **Total** |
| **Test 1**  | **Test 2** | **Other components (Seminars/quiz/assignments)** |
| 10 | 10 | 5 | 75 | 100 |

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| --- | --- |
| **Core Course - XII** | **Core XII-MDP** |
| **Title of the Course:** | **TOOLS AND THEIR APPLICATION IN BIOINFORMATICS (PRACTICALS)** |
| **Credits:** | **4** |
| **Pre-requisites, if any:** | Students should be familiar with the basics of tools and its application |
| **Course Objectives:**1. To provide knowledge on practical handling of various databases, online tools and softwares used to analyze biological data
2. To gain practical knowledge and skill on sequence analysis, phylogenetic analysis and sequence conversion
3. To provide insights on molecular modeling, molecular docking methods, molecular interaction and visualization tools
 |
| **Course Outcomes:** |
| 1. On Successful completion of the course, the student will be able to | K1 |
| 2. Understand the importance of structural studies in bioinformatics | K2 |
| 3. Gain an insight about the forces that determines the structure of biological macromolecules | K3 |
| 4. Apply the knowledge gained to interpret the properties of biological macromolecules | K4 |
| 5. Apply molecular docking and analyze the interactions | K5 & K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
| **Keywords:** PubMed, Sequence analysis, BLAST, Sequence conversions. |
| **UNITS** |
| **UNIT I**Bibliographic search on the Internet – PubMed: The students should search PubMed (NCBI) and obtain information about a particular topic, which may be suggested by the teacher. Browsing database – Each student should independently access at least one database described in <http://nar.oxfordjournals.org/>content/vol34/suppl\_1/index.dtl and describe its contents. |
| **UNIT II**Blast search – Each student is given a specific protein or DNA sequence, which is used in the search through the Blast web page (NCBI) PsiBlast – Each student is given a specific protein or DNA sequence, which is used in the search through the PsiBlast web page (NCBI) Global alignment using Needleman – Wunsch (NW) algorithm (Emboss Needle) – student is given a pair of sequences to perform a global alignment using the NW algorithm. DotPlot – studentcreates a DotPlot display of a pair of sequences Multiple sequence alignment – Each student creates an alignment of a set of 6 to 10 sequences and displays the results appropriately. |

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| **UNIT III**Restriction Site analyses – Given a DNA sequence and a particular restriction enzyme, the student identifies the cleavage sites. Comparative genomics using Vista Phylogenetic tree construction (UPGMA) – Given a set of 6 to 10 protein or DNA sequences, the student uses UPGMA to construct a phylogenetic tree. Phylogenetic tree construction (Neighbour Joining)– Given a set of 6 to 10 protein or DNA sequences, the student uses Neighbour Joining to construct a phylogenetic tree (MEGAX) |
| **UNIT IV**Sequence conversions – The student converts a DNA sequence into the complementary RNA and vice versa. The student translates the DNA sequence in all six reading frames to the protein sequence and a protein sequence and a protein into the respective DNA sequence, choosing an appropriate codon usage table Gene discovery – Given a large DNA sequence (such as e.g. a small portion of an eukaryotic genome) the student predicts all possible genes. Protein structure calculations – Given a small protein/ peptide structure, the student calculates and tabulates bond lengths, bond angles, and torsion angles, and identifies hydrogen bonds,Molecular surface calculations. Ramachandran plot – Given a protein structure, the students creates and displays its Ramchandran plot Structural superposition – Given a pair of similar protein structures the student performs a structural superposition and calculates the similarities/differences. Homology Modeling using Online Tools (Swiss Model). Moleculardynamics simulation using simple models and continuous potentials, preparing parameter file using Gromacs |
| **UNIT V**Chemical library search, molecular file format conversion. Exact, similar substructure searching in chemical databases. Drug likeness prediction, Lipinski’s rule of five, calculating the number of H – bond acceptors, rotatable bonds, calculated log p, topological polar surface area, solvent accessible area, molecular connectivity indices, Permeability prediction, Caco – 2 cell permeability ,Human intestinal absorption, Skin permeability, Blood – brain barrier permeability – metabolism prediction – Structure liability, Cytochrome P450s induction, inhibition and specificity- Pharmacokinetics prediction – Toxicity prediction – Mutagenicity,Carcinogenicity Testing. Pharmacophore search- Active site prediction- molecular docking and interaction analysis (Autodock and Hex softwares) |
| **Recommended Text**1. K.Mani and N.Vijayaraj (2004) “Bioinformatics – A Practical Approach” Aparnaa Publication, Coimbatore, India
2. C.Gibas and P.Jambeck (2001) “Developing Bioinformatics Computer Skills” Shroff Publishers and Distributors Pvt Ltd, Mumbai, India
 |
| **Reference Books**1. The manuals corresponding to the software would serve as Reference Books. |
| **Reading List**1. http://www.rcsb.org/pdb/101/static101.do?p=education\_discussion/Looking- atStructures/methods.html
2. <http://bioinformaticsweb.net/tools.html>
3. <https://www.bits.vib.be/index.php/training/122-basic-bioinformatics>
4. <http://bioinformaticssoftwareandtools.co.in/>
5. <http://www.genscript.com/tools.html>
 |

**Mapping with Programme Outcomes:**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | L | S | M | L | M | M | S | M |
| **CO 2** | S | S | M | M | S | S | M | S | S | S |
| **CO 3** | M | M | S | S | L | M | L | S | M | S |
| **CO 4** | S | S | S | S | S | M | S | S | S | S |
| **CO 5** | S | S | M | S | M | S | S | S | S | S |

**S-Strong M-Medium L-Low**

**Method of Evaluation**

|  |  |  |
| --- | --- | --- |
| **Internal Assessment** | **End semester exams** | **Total** |
| **Test 1**  | **Test 2** | **Other components (Seminars/quiz/assignments)** |
| 10 | 10 | 5 | 75 | 100 |

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| --- | --- |
| **Elective Course - III** | **Elective III-MDP** |
| **Title of the****Course:** |  **MEDICAL INFORMATICS** |
| **Credits:** | **3** |
| **Pre-requisites, if any:** | Students should be familiar with the basics of Medical Informatics and electronic health records. |
| **Course Objectives:**1. To understand the fundamentals of the field in the context of the effective use of biomedical data, information, and knowledge.
2. To analyze strategies for the management of biomedical information.
3. To understand the importance of health record contents across the health system.
 |
| **Course Outcomes:** |
| 1. Students understand the health informatics concepts. | K1 |
| 2. Gains an insight on the health care findings with data visualizations | K2 |
| 3. Identifies standards for exchange of health information. | K3 |
| 4. Analyze technologies for the management of health information. | K4 |
| 5. Effective use of biomedical data, information, and knowledge. | K5 & K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
| **Keywords:** Clinical database, Electronic health report, Patient Informatics, Telehealth |
| **UNITS** |
| **UNIT I**Overview of Medical Informatics – Components – Healthcare Systems- Clinical Databases – Confidentiality and Data Protection. |
| **UNIT II**Electronic Patient Records / Electronic Health Records – Clinical Coding – Standards and Interoperability. |
| **UNIT III**System Design and Evaluation – Decision Support – Human Computer Interaction- Patient Informatics – Online Medical Resources |
| **UNIT IV**Telehealth and Telecare – Telepathology – Evidence Based Medicine – Clinical Practice Guidelines –Disease Management and Disease Registries – Electronic Prescribing. |

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| **UNIT V**Picture Archiving and Communication Systems – Public Health Informatics –Emerging Trends. |
| **Reference Books**1. Robert E.Hoyt and Ann Yoshihashi (2010), Medical Informatics: Practical Guide for Healthcare and Information Technology Professionals, Fourth Edition, Lulu.com.
2. Edward H.Shortliffe and James J.Cimino (2014), Biomedical Informatics: Computer Applications in Healthcare and Biomedicine, Springer.
3. Hsinchun Chen, Sherrilynne S.Fuller, Carol Friedman and William Hersh (2005), Medical Informatics: Knowledge Management and Data Mining in Biomedicine, Springer.
 |

**Mapping with Programme Outcomes:**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | S | S | M | L | M | M | S | M |
| **CO 2** | S | S | M | M | S | S | M | S | S | S |
| **CO 3** | L | M | S | S | M | M | M | S | S | S |
| **CO 4** | S | S | S | S | S | M | S | S | S | S |
| **CO 5** | S | S | M | S | M | S | S | S | S | M |

**S-Strong M-Medium L-Low**

**Method of Evaluation**

|  |  |  |
| --- | --- | --- |
| **Internal Assessment** | **End semester exams** | **Total** |
| **Test 1**  | **Test 2** | **Other components (Seminars/quiz/assignments)** |
| 10 | 10 | 5 | 75 | 100 |

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| **Skill enhancement Course - II** | **Extra Disciplinary II-MDP** |
| **Title of the Course:** | **POTENTIAL APPLICATIONS AND COMMERCIAL ASPECTS OF BIOINFORMATICS** |
| **Credits:** | **2** |
| **Pre-requisites, if any:** | Students should be familiar with the basics of commercial aspects of Bioinformatics. |
| **Course Objectives:**1. Design the biological targets and properties of the small molecule under investigation
2. Better understanding of the drug discovery and development process
3. Understand the process of personalized medicine and drug prescription
 |
| **Course Outcomes:** |
| 1. To get introduced to the basic concepts of Bioinformatics | K1 |
| 2. To understand the basics of sequence alignment and analysis. | K2 |
| 3. To gain knowledge about various concepts employed in drug discovery. | K3 |
| 4. To analyze the biological data. | K4 |
| 5. Evaluating the applications towards personalized medicine. | K5 &K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
| **Keywords:** Drug discovery, Pharmacogenomics, Personalized medicine, Genetics. |
| **UNITS** |
| **UNIT I**Visualization of sequence data: What a sequence reveals about the biological function of a gene |
| **UNIT II**Applications of bioinformatics in drug discovery |
| **UNIT III**Genetic basis of disease Role of genetics in future approaches to healthcare, Genetic medicine, human disease and genes |
| **UNIT IV**Pharmacogenomics, Personalized medicine and gene-based diagnostics: Definition of personalized medicine, Conventional medicine versus personalized medicine, Role of genetics in development of personalized medicines. |
| **UNIT V**Introduction to ethical issues, Legal, ethical and commercial ramifications of bioinformatics Ethical and Regulatory Aspects of Personalized Medicine. |

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| **Reference Books**1. N.Gautham (2006) ‘Bioinformatics’ Narosa Publishing Company, New Delhi.
2. V.R. Srinivas (2005) ‘Bioinformatics: A Modern Approach’ Prentice-Hall of India Private Limited New Delhi, India.
3. D.Mount (2000) ‘Bioinformatics: Sequences and Genome Analysis’ Cold Spring Harbor Laboratory Press, Cold Spring Harbor, USA.
4. D.Higgins and W.Taylor. (eds) (2000) ‘Bioinformatics: Sequences, Structures and Databanks’ Oxford University Press, Oxford, UK
 |
| **Reading List**1. <https://www.researchgate.net/publication/233556197_Legal_issues_in_bioinformatics>
2. [https://link.springer.com/content/pdf/10.1057%2Fpalgrave.jcb.3040034.pdf](https://link.springer.com/content/pdf/10.1057/palgrave.jcb.3040034.pdf)
3. [https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5421137/#:~:text=Bioinformatic%20an](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5421137/#%3A~%3Atext%3DBioinformatic%20analysis%20can%20not%20only%2Ceffects%20and%20predict%20drug%20resistance) [alysis%20can%20not%20only,effects%20and%20predict%20drug%20resistance.](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5421137/#%3A~%3Atext%3DBioinformatic%20analysis%20can%20not%20only%2Ceffects%20and%20predict%20drug%20resistance)
4. <https://bcmj.org/articles/role-genetics-medicine-future-precision-medicine>
 |

**Mapping with Programme Outcomes:**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | L | S | M | L | M | M | S | M |
| **CO 2** | S | S | M | M | S | S | M | S | S | S |
| **CO 3** | M | M | S | S | L | M | L | S | M | S |
| **CO 4** | S | S | S | S | S | M | S | S | S | S |
| **CO 5** | S | S | M | S | M | S | S | S | S | S |

**S-Strong M-Medium L-Low**

**Method of Evaluation**

|  |  |  |
| --- | --- | --- |
| **Internal Assessment** | **End semester exams** | **Total** |
| **Test 1**  | **Test 2** | **Other components (Seminars/quiz/assignments)** |
| 10 | 10 | 5 | 75 | 100 |

**SEMESTER – IV**

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| --- | --- |
| **Core Course - XIII** | **Core XIII-MDP** |
| **Title of the Course:** | **ADVANCED TOPICS IN BIOINFORMATICS** |
| **Credits:** | **4** |
| **Pre-requisites, if any:** | Students should be familiar with the advanced topics of Bioinformatics. |
| **Course Objectives:**1. To develop a quantitative understanding of recent and emerging fields of Bioinformatics.
2. To provide hands on experience of handling the genomic and proteomic datasets
3. To provide information about the methods used in immunological bioinformatics
 |
| **Course Outcomes:** |
| 1. Understand the application of information technology to immunology | K1 |
| 2. Study informatics-based approaches for prediction of epitopes and immuno- diagnostic tools. | K2 |
| 3. Students will be able to analyze the raw reads of sequences | K3 |
| 4. Learns information about the methods used in immunological bioinformatics | K4 |
| 5. Apply genomic and proteomic datasets in research. | K5 & K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
| **Keywords:** Sequence Alignment, Nutrigenomics, Chemo genomics, Metagenomics, |
| **UNITS** |
| **UNIT I**Comparative Genomics Relationship of phylogenetic analysis to sequence alignment, genome Complexity and phylogenetic analysis –Maximum parsimony method, Distance methods. Reliability of phylogenetic predictions- Complications from phylogenetic analysis –Phylip &Paup software. DNA computers – Principle &amp; working. |

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| **UNIT II**Nutrigenomics-Nutritional genetics – nutritional genomics-genetic nutrition-gene directed nutrition with Reference to diabetes, cardiovascular diseases and obesity and neuro genomics- short notes on Herbal informatics (medicinal foods). |
| **UNIT III**Chemo genomics-Definition – Effect of chemicals on genes – delayed mutations –Interaction of molecules (small & big) with DNA intercalation – case study with copper deficiency leading to diseases, Role of p53 –Oncogene changes. |

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| **UNIT IV**Metagenomics and Molecular Evolutionary Pathways Definition of metagenomics – application of genomics to cultured and uncultured microorganisms, metagenomics of microbial communities, cladistics – Evolutionary relationships – evolution of nucleic acids, proteins and enzymes associated SNPs. |
| **UNIT V**Immuno informatics Introduction – Databases – The International ImmunoGenetics of Information – Immuno Ontology Concepts -Tools, Web Resources for analysis of immune molecules - In Silico Prediction of QSAR Based Properties of Class I and Class II MHC, Epitope Prediction – Allergenicity Prediction – Vaccine Designing - Antigen and Antibody reactions - Antigen and Antibody interactions - Understanding the immune system by computer aided modeling. |
| **Reference Books**1. Jacoby, E (2005) Chemogenomics- Knowledge-based Approaches to Drug Discovery, World Scientific.
2. Rothstein, MA, (2003) Pharmacogenomics, Wiley-Liss.
3. Chakraborty, C; Bhattacharya, A (2005) Pharmacogenomics, Biotech Publishers.
4. Rimbach, GH (2005), Nutrigenomics, CRC.
5. Hamadeh, HK, Afshari, CA (2004) Toxicogenomics : Principles and Applications Wiley-Liss.
6. Schonbach, C, Ranganathan, Shoba, Brusic, Vladimir (2008) Immunoinformatics, Springer.
 |
| **Reading List**1. <https://pubmed.ncbi.nlm.nih.gov/25048118/>
2. [https://www.sciencedirect.com/topics/agricultural-and-biological-](https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/immunoinformatics) [sciences/immunoinformatics](https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/immunoinformatics)
3. <https://www.nutritionsociety.org/blog/nutrigenomics-basics>
4. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC261895/>
5. <https://www.ncbi.nlm.nih.gov/books/NBK54011/>.
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**Mapping with Programme Outcomes:**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | L | S | M | L | M | M | S | M |
| **CO 2** | S | S | S | L | S | S | M | S | S | S |
| **CO 3** | S | M | S | S | L | M | L | S | S | L |
| **CO 4** | S | S | S | S | S | M | S | S | S | S |
| **CO 5** | S | S | L | S | S | S | S | S | S | S |

**S-Strong M-Medium L-Low**

**Method of Evaluation**

|  |  |  |
| --- | --- | --- |
| **Internal Assessment** | **End semester exams** | **Total** |
| **Test 1**  | **Test 2** | **Other components (Seminars/quiz/assignments)** |
| 10 | 10 | 5 | 75 | 100 |

|  |  |
| --- | --- |
| **Core Course - XIV** | **Core XIV-MDP** |
| **Title of the Course:** | **TOOLS AND THEIR APPLICATIONS IN BIOINFORMATICS (PRACTICALS)** |
| **Credits:** | **4** |
| **Pre-requisites, if any:** | Students should be familiar with the advanced topics of Bioinformatics. |
| **Course Objectives:**1. To develop a quantitative understanding of recent and emerging fields of Bioinformatics.
2. To provide hands on experience of handling the genomic and proteomic datasets
3. To provide information about the methods used in bioinformatics
 |
| **Course Outcomes:** |
| 1. Understand the application of information technology to biology | K1 |
| 2. Study informatics-based approaches for sequence analysis and alignment | K2 |
| 3. Students will be able to analyze the raw reads of sequences | K3 |
| 4. Learns information about the methods used in immunological bioinformatics | K4 |
| 5. Apply genomic and proteomic datasets in inferring Evolutionary relationship. | K5 & K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
| **Keywords:** Sequence Alignment, Nutrigenomics, Chemo genomics, Metagenomics, |
| **UNITS** |
| **UNIT I**search PubMed (www.ncbi.nlm.nih.gov) and obtain information about a particular topic, which may be suggested by the teacher. Browsing database – Each student should independently access at least one database described in http://nar.oxfordjournals.org/ content/vol34/suppl\_1/index.dtl and describe its contents |
| **UNIT II**Blast search – Each student is given a specific protein or DNA sequence, which is used in the search through the Blast web page (www.ncbi.nlm.nih.gov). PsiBlast – Each student is given a specific protein or DNA sequence, which is used in the search through the PsiBlast web page (www.ncbi.nlm.nih.gov) |
| **UNIT III** Global alignment using Needleman – Wunsch (NW) algorithm – students are given a pair of sequences to perform a global alignment using the NW algorithm. DotPlot – student creates a DotPlot display of a pair of sequences Multiple sequence alignment – Each student creates an alignment of a set of 6 to 10 sequences and displays the results appropriately Restriction Site analyses – Given a DNA sequence and a particular restriction enzyme, the student identifies the cleavage sites. Comparative genomics using Vista Phylogenetic tree construction (UPGMA) – Given a set of 6 to 10 protein or DNA sequences, the student uses UPGMA to construct a phylogenetic tree.Phylogenetic tree construction (Neighbour Joining) – Given a set of 6to 10 protein or DNA sequences, the student uses Neighbour Joining to construct a phylogenetic tree |

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| **UNIT IV**Sequence conversions – The student converts a DNA sequence into the complementary RNA and vice versa. The student translates the DNA sequence in all six reading frames to the protein sequence and a protein sequence and a protein into the respective DNA sequence, choosing an appropriate codon usage table Gene discovery – Given a large DNA sequence (such as e.g. a small portion of an eukaryotic genome) the student predicts all possible genes. Protein structure calculations – Given a small protein/ peptide structure, the student calculates and tabulates bond lengths, bond angles, and torsion angles, and identifies hydrogen bonds, Molecular surface calculations. Ramachandran plot – Given a protein structure, the students creates and displays its Ramchandran plot Structural superposition – Given a pair of similar protein structures the student performs a structural superposition and calculates the similarities/differences.Molecular dynamics simulation using simple models and continuous potentials, preparing parameter file using Gromacs. |
| **UNIT V**Chemical library search, molecular file format conversion. Exact, similar substructure searching in chemical databases. Drug likeness prediction, Lipinski’s rule of five, calculating the number of H – bond acceptors, rotatable bonds, calculated log p, topological polar surface area, solvent accessible area, molecular connectivity indices, Permeability prediction, Caco – 2 cell permeability ,Human intestinal absorption, Skin permeability, Blood – brain barrier permeability – metabolism prediction – Structure liability, Cytochrome P450s. induction, inhibition and specificity- Pharmacokinetics prediction – Toxicity prediction – Mutagenicity, Carcinogenicity Testing. (www.bmdrc.org/) Pharmacophore Search – Active site prediction - Molecular docking and interaction analysis ( Autodock and Hex Softwares) |
| **Reference Books**1.K.Mani and N.Vijayaraj (2004) “Bioinformatics – A Practical Approach” Aparnaa Publication, Coimbatore, India 2. C.Gibas and P.Jambeck (2001) “Developing Bioinformatics Computer Skills” Shroff Publishers and Distributors Pvt Ltd, Mumbai, India |
| **Reading List**https://pubmed.ncbi.nlm.nih.gov/25048118/https://www.sciencedirect.com/topics/agricultural-and-biological- [sciences/immunoinformatics](https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/immunoinformatics)https://www.nutritionsociety.org/blog/nutrigenomics-basicshttps://www.ncbi.nlm.nih.gov/pmc/articles/PMC261895/https://www.ncbi.nlm.nih.gov/books/NBK54011/. |

**Mapping with Programme Outcomes:**

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| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | L | S | M | L | M | M | S | M |
| **CO 2** | S | S | S | L | S | S | M | S | S | S |
| **CO 3** | S | M | S | S | L | M | L | S | S | L |
| **CO 4** | S | S | S | S | S | M | S | S | S | S |
| **CO 5** | S | S | L | S | S | S | S | S | S | S |

**S-Strong M-Medium L-Low**

**Method of Evaluation**

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| **Internal Assessment** | **End semester exams** | **Total** |
| **Test 1**  | **Test 2** | **Other components (Seminars/quiz/assignments)** |
| 10 | 10 | 5 | 75 | 100 |

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| **Elective Course - IV** | **Elective IV-MDP** |
| **Title of the Course:** | **SYSTEMS BIOLOGY: METHODS AND APPLICATIONS** |
| **Credits:** | **3** |
| **Pre-requisites, if any:** | Students should be familiar with the basics concepts and methods in systems biology. |
| **Course Objectives:**1. To introduce the basic concepts of Systems biology
2. To train the students in designing a new organism through modeling network concepts manipulating them for biological applications.
 |
| **Course Outcomes:** |
| 1. Understand the concepts and insights of systems biology | K1 |
| 2. Analyze and model various biological models | K2 |
| 3. Apply practical handling in systems biology online tools | K3 |
| 4. Analyze the biological aspects efficiently | K4 |
| 5. Designing a new organism through modeling network concepts | K5 & K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
| **Keywords:** Sequence Alignment, Nutrigenomics, Chemo genomics, Metagenomics, |
| **UNITS** |
| **UNIT I**Basic concepts of System biology- Enabling information and integration for systems biology, Databases for Systems biology, Natural language processing and ontology-Enhanced biomedical literature mining for Systems Biology. Biological Networks from *E.coli* to Human Tissue – Regulatory Networks in Developmental Processes - Gene networks - Signal Transduction – Protein to Protein Interaction Networks. |
| **UNIT II**Introduction to Networks and Graphs- Discrete approach to Network modeling Estimation modeling and simulation-Computational models of biochemical reaction networks - Metabolic Flux analysis- Integrated Regulated and Metabolic Models - Dynamics and Complexity ofIntercellular Networks- Reconstruction of Metabolic Network from Genome Information Computational Models for Circadian rhythms - Deterministic Versus Stochastic approaches. |
| **UNIT III**Multiscale Representation of Cells and emerging phenotypes Developmental models - Fixed- Geometry spatial patterning -Regulated cell growth and division - Dynamic geometry; mechanical models- Spatio temporal Systems biology – Inferring Networks for Diseases - |
| **UNIT IV**Softwares and Tools for Systems Biology - Mat lab Gepasi, Cell Designer, Cellerator – Systems Biology WorkBench -Cytomics -From Cell States to Predictive medicine- The IUPSPhysiome project E-Cell Computer Simulation of the Cell -Virtual Cell - Genesis too. |

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| **UNIT V**Applications and Perspectives of Systems biology - Computable models- Representation (SBML,CellML), Methods (PDEs, Petri Nets, Cellular Automata) - Developments and trends of Systems biology- Long and medium term goals of Systems biology- The potential applications of Systems biology - Microarray analysis and gene networks- BRB Array tools - Synthetic biology – Implications and Use. |
| **Recommended Books**1. Andres Kriete, Roland Eils (2005), “Computational Systems Biology”, Academic Press. |
| **Reference Books**1. Peter Bringmann (2007), Systems Biology: Applications And Perspectives, Springer,
2. Andrzej K. Konopka (2007) Systems Biology: Principles, Methods, and Concepts, CRC Press
3. Lilia Alberghina, Hans V. Westerhoff, (2005), Systems Biology: Definitions and Perspectives, Birkhäuser.
 |
| **Reading List**1. [http://Sysbio.Med.Harvard.Edu/](http://sysbio.med.harvard.edu/)
2. [www.Systemsbiology.Org](http://www.systemsbiology.org/)
3. [www.Systemsbiology.Ucsd.Edu/](http://www.systemsbiology.ucsd.edu/)
4. [www.Sysbio.Org/](http://www.sysbio.org/)
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**Mapping with Programme Outcomes:**

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| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | M | S | M | L | M | M | S | M |
| **CO 2** | S | S | L | M | S | S | M | S | S | L |
| **CO 3** | S | S | S | S | L | M | L | S | M | S |
| **CO 4** | S | S | S | M | S | M | S | S | S | S |
| **CO 5** | S | S | M | S | M | S | S | S | S | S |

**S-Strong M-Medium L-Low**

**Method of Evaluation**

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| **Internal Assessment** | **End semester exams** | **Total** |
| **Test 1**  | **Test 2** | **Other components (Seminars/quiz/assignments)** |
| 10 | 10 | 5 | 75 | 100 |

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| **Elective Course - V** | **Elective V-MDP** |
| **Title of the Course:** | **MICROARRAY TECHNOLOGIES AND ITS APPLICATIONS** |
| **Credits:** | **3** |
| **Pre-requisites, if any:** | Students should be familiar with the basics of microarray technologies and its applications. |
| **Course Objectives:**1. To understand the expression profile of an organism
2. To prepare a microarray and to understand the various steps in it
3. To design an experiment and to analyze the result
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| **Course Outcomes:** |
| 1. Students understand the mechanism in microarray technology | K1 |
| 2. Students understand the steps involved in microarray technology | K2 |
| 3. Helps in understanding the various applications of this technology | K3 |
| 4. Helps in personalizing the treatment of different disease | K4 |
| 5. The interpretation of a typical microarray is possible. | K5 & K6 |
| **K1** - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** – Create |
| **Keywords:** Microarray, Probes selection, Expression profiling. |
| **UNITS** |
| **UNIT I**Introduction to Microarrays – The Basics of Experimental Design –Controls and Replicates – Experimental Designs- Designing and Producing Microarrays |
| **UNIT II**Probe Selection – cDNA and Amplicon Probes –Oligonucleotide Probes – Preparing Arrays. Sample Collection and Labeling – RNA Extraction –cDNA Production – Labeling Methods and Signal Amplification. |
| **UNIT III**RNA Amplification Probe Selection – cDNA and Amplicon Probes –Oligonucleotide Probes. Hybridization and Scanning |
| **UNIT IV**Preparing Arrays- Genome Arrays – Exon Arrays – Amplicon and BAC Arrays –Oligonucleotide Arrays- Tiling Arrays. Microarray Data Repositories – Array Express – GeneExpression Omnibus (GEO) –Other Repositories |
| **UNIT V**Expression Profiling Human Disease – Array CGH – SNPs and Genotyping-Protein Binding Arrays –Cell and Tissue Arrays – Protein Arrays – Antibody Arrays |
| **Recommended Texts**1. Steve Russell, Lisa Meadows, Roslin Russell (2008), Microarray Technology in Practice, Elsevier.
2. Francesco Falciani (2007), Microarray Technology Through Applications, Taylor & Francis.
3. Abhilash M. (2010), Introduction to Bioinformatics and Microarray Technology, CBS Publishers & Distributors
4. B.R. Jordan (2001), DNA Microarrays: Gene Expression Applications (Principles and Practice), Springer.
5. Kresten Ovesen, Ulrich Matthiesen (2010), DNA: Fingerprinting, Sequencing & Chips (Dna: Properties and Modifications, Functions and Interactions, Recombination and Applications), Nova Science Publishers Inc.
 |
| **Reference Books**1.Peter Bringmann( 2007) , Systems Biology: Applications And Perspectives, Published by Springer, 2. Andrzej K. Konopka (2007) Systems Biology: Principles, Methods, and Concepts, Published by CRC Press 3. Lilia Alberghina, Hans V. Westerhoff, (2005) , Systems Biology: Definitions and Perspectives, Published by Birkhäuser. |

**Mapping with Programme Outcomes:**

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| **COs** | **PO1** | **PO2** | **PO3** | **PO4** | **PO5** | **PO6** | **PO7** | **PO8** | **PO9** | **PO10** |
| **CO1** | S | S | S | S | M | L | M | M | S | M |
| **CO 2** | S | S | M | M | S | S | M | S | S | S |
| **CO 3** | S | M | S | S | L | M | L | S | M | S |
| **CO 4** | S | S | S | S | S | M | S | M | S | L |
| **CO 5** | S | M | M | S | M | S | S | S | L | S |

**S-Strong M-Medium L-Low**

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