SARDAR PATEL UNIVERSITY
Vallabh Vidyanagar, Gujarat
(Reaccredited with 'A' Grade by NAAC (CGPA 3.25)
Syllabus with effect from the Academic Year 2022-2023

PROGRAMME STRUCTURE
M.Sc. Biochemistry Semester: III

Programme Outcome (PO) - For M.Sc. Biochemistry Programme	1. Biochemistry masters students will be able to comprehend fundamental Biochemistry principles underlying normal physiology and pathogenesis. 2. They will develop proficiency in Biochemistry Laboratory experiments as well as theory. 3. They will be able to translate their knowledge with a skilful job at various industries and research labs. 4. The students will become employable in the fields of Quality Assurance, Production, Research and Teaching in Biopharmaceuticals, Neutraceuticals, Dairy, Agriculture, Environment, Clinical, Biotechnology and Life sciences.
Programme Specific Outcome (PSO) - For MSc Biochemistry Semester - III	1. The students will learn principles of important instruments useful in Biochemistry experiments. 2. The Biochemistry students will further develop their proficiency in Biochemistry Laboratory experiments as well as theory. 3. They will be able to design and carry out standard Biochemistry experiments on their own.

To Pass	(1) At least 40% marks in each paper at the University Examination and 40% aggregate marks in Internal and External Assessment. (2) At least 33% Marks in each paper in Internal Assessment.

Course Type	Course Code	Name Of Course	Theory/ Practical	Credit	Exam Duration in hrs	Component of Marks		
						Internal Total	External Total	Total Total
Core Course	PS03CBIC51	Clinical Physiology	T	4	3	30	70	100
	PS03CBIC52	Genetic Engineering	T	4	3	30	70	100
	PS03CBIC53	Toxicology	T	4	3	30	70	100
	PS03CBIC54	Practicals	P	4	3	30	70	100
	PS03CBIC55	Practicals	P	4	3	30	70	100
Elective Course (Any One)	PS03EBIC51	Biomanufacturing principles and practices	T	4	3	30	70	100
	PS02EBIC52	Plant Biochemistry	T	4	3	30	70	100
	PS02EBIC53	Bioinformatics	T	4	3	30	70	100

(Master of Science) (Biochemistry)
(M.Sc.) (Biochemistry) Semester (III)

Course Code	PS03CBIC51	Title of the Course	Clinical Physiology
Total Credits of the Course	04	Hours per Week	03

Course Objectives:	Student should be able to: i. Correlate various systems of the human body with homeostasis. ii. Understand pathophysiological conditions occurring in humans.

Course Content		
Unit	Description	Weightage* (%)
1.	Homeostasis and the organization of body fluids, Control of Homeostasis, Positive and negative Feedback systems, Homeostatic Imbalances. An overview of human circulatory system. Disorders of circulatory system: respiratory acidosis and alkalosis, metabolic acidosis and alkalosis, Hypoxia, coagulation disorders, hypertension, thalassaemias and anemias.	25
2.	An overview of digestive system. Hormonal and neural regulation of GIT, Gastritis, GIT obstruction, ulcers An overview of Muscular System. Disorders of muscular system: Myasthenia Gravis, muscular dystrophy, fibromyalgia, muscular atrophy and hypertrophy, Rigor Mortis.	25
3.	An overview of Nervous System. Disorders of nervous system: multiple sclerosis,epilepsy, neuropathy, Guillain-Barre syndrome. Neurotoxicity: neurotoxins, anaesthetics, neuro-transmission inhibitors. An overview of Respiratory System. Disorders of respiratory system: Asthama, Chronic Obstructive Pulmonary Disease, Cystic fibrosis, Penumonia, Pulmonary edema.	25
4.	An overview of human urinary system. Role of kidney in body water, electrolyte and acid-base balance. Renal malfunctions and hemodialysis. Nephrotic syndrome, Kidney stone, UTI Disorders of reproductive systems: prostate disorders, cryptorchidism and hernias, PMS, PMDD. Birth control: Physiology of birth control methods.	25

Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Students should be able to read and understand diagnostic reports.
2.	Student should be able to understand, how to maintain health

Suggested References:	
Sr. No.	References
1.	Hall, J. E., & Guyton, A. C. (2016) Textbook of medical physiology (13th Edn.). Elsevier, Philadelphia.
2.	Barrett, K. E., & Ganong, W. F. (2019). Ganong's review of medical physiology (26th Edn.) McGraw-Hill Medical, New York.
3.	Tortora, G. J., & Grabowski, S. R. (2017). Principles of Anatomy and Physiology (15th Edn). HarperCollins College, New York.

On-line resources to be used if available as reference material

On-line Resources

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(Master of Science) (Biochemistry)
(M.Sc.) (Biochemistry) Semester (III)

Course Code	PS03CBIC52	Title of the Course	GENETIC ENGINEERING
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1 To understand the basic tools and techniques used for manipulation of DNA 2. To become familiar with the strategies for production of transgenic organisms 2. To learn applications of genetic engineering in agriculture, industry and medicine

Course Content		
Unit	Description	Weightage* (%)
1.	Concept and importance of Genetic Engineering; General strategies and Steps involved in gene cloning: Extraction and purification of DNA and RNA from bacteria, virus, plant and animal cells; physical and enzymatic methods for cutting DNA; Introduction of DNA into host cells; screening and selection methods for recombinant clones.	25%
2.	Basic properties and cloning strategies for vectors derived from Plasmids, bacteriophages and their chimeric vectors, YAC, BAC, HAC/MAC and viral vectors for Plant and animal cells. Salient features of expression vectors for heterologous expression in *E. coli*, Yeast, insect and mammalian system. Shuttle vectors and gene trapping vectors. Vector design and modification strategies; chemical synthesis of oligonucleotides.	25%
3.	DNA sequencing and sequence assembly: Maxam-Gilbert's and Sanger's methods, Shot gun sequencing, Next generation sequencing strategies for large genomes. DNA mapping and DNA fingerprinting: Physical and molecular mapping, Hybridization and PCR based methods of fingerprinting. Site directed mutagenesis: Methods and applications. Polymerase Chain Reaction: Principle and basic types of PCR; Reverse Transcription and Real Time PCRs. Construction genomic and cDNA libraries;	25%
4.	Applications of Genetic engineering in improvement of plants, animals	25%

	and microbes; Gene editing and its applications; Metagenomics and Metabolic engineering; Gene therapy; Restriction and regulations for the release of GMOs; Biosafety and levels of Physical and Biological containment; The Indian Guidelines for release and use of GM organisms.	

Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Students will learn about the basic tools to work with DNA and general methods for cloning DNA sequences (structural gene sequences and DNA).
2.	The student will acquire knowledge on advanced strategies of genetic engineering to make biotech products. Selection of vectors, cloning strategies, optimization of sequences, mutagenesis and expression of DNA sequences
3.	Apart from this, students will also become familiar with the norms for production and release of GMOs.
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Suggested References:	
Sr. No.	References
1.	Principles of Gene Manipulation and Genomics" by Sandy B Primrose and Richard Twyman
2.	Genetic Engineering by Smita Rastogi and Neelam Pathak
3.	Gene cloning: An introduction. T. A. Brown

On-line resources to be used if available as reference material
On-line Resources

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(Master of Science) (Biochemistry)
(M.Sc.) (Biochemistry) Semester (III)

Course Code	PS03CBIC53	Title of the Course	Toxicology
Total Credits of the Course	04	Hours per Week	03

Course Objectives:	i. To learn about the dose-response relationships and understand the tocixity of various substances ii. To comprehend the knowledge of absorption, distribution, metabolism and elimination of xenobiotics iii. To provide an overview on legislative measures in the field of food, drugs and environmental toxciants

Course Content		
Unit	Description	Weightage* (%)
1.	Definition and scope of toxicology: Eco-toxicology and its environmental significance, Biochemical Aspects of Toxicology Toxic effects: Basic for general classification & nature. Measurement of Dose-Response Relationships, Synergism and Antagonism Acute and Chronic exposures, Factors influencing Toxicity. Pharmacodynamics & Chemodynamics, dose conversion between animals and human Diagnosis of toxic changes in liver and kidneys: Metabolism of drugs: paracetamol and aspirin with their toxic effects on tissues.	25
2.	Xenobiotics Metabolism: Absorption & distribution. Phase I reactions. Oxidation, Reduction, Hydrolysis and Hydration. Phase II reaction/Conjugation: Methylation, Glutathione and amino acid conjugation. Detoxification. Biochemical basis of toxicity: Metabolism of Toxicity: Disturbances of Excitable membrane function. Altered calcium Homeostasis. Covalent binding of cellular macromolecules & Genotoxicity. Tissue specificity of Toxicity. Toxicity testing: Models for toxicity testing; Acute and Chronic toxicology testing, Experimental design; Genetic toxicity testing & Mutagenesis assays In vitro Test systems – Bacterial Mutation Test, Ames test, *In vivo* Mammalian Mutation tests –DNA repair assays, Chromosome damage test, Evaluation of Apoptosis and necrosis	25
3.	Pesticides: Insecticides: Organochlorines, Anti cholinesterases-Organophosphates and Carbamates, Fungicides: Captan, Di-thio carbamates, Herbicides:2,4 D, Atrazine; Food additives: Preservatives,	25

	Processing aids, Flavor and taste modifiers, Nutritional additives; Role of diet in cardio-vascular disease and cancer. Toxicology of food additives; Metal Toxicity: Toxicology of Arsenic, mercury, lead and cadmium.	
4.	Regulatory Toxicology: Rules and regulations of Nuclear Regulatory Commission (NRC); Environmental Protection Agency (EPA); Food and Drug Administration (FDA); Drug Enforcement Administration (DEA); Occupational Safety and Health Assessment (OSHA); Committee for Purpose of Control and supervision of experimental on animals (CPCSEA)	25

Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Learn the toxicity testing methods and designing of animal experimentations in pharmaceutical and drug industries or research organizations
2.	Correlate concentrations of doses, duration of exposure and animal responses

Suggested References:

Sr. No.	References
1.	Klaassen, C., D., (Ed) (2013). Casarett and Doull's toxicology : the basic science of poisons. McGraw-Hill Education, New York.
2.	Timbrell, J. A., (2008). Principles of biochemical toxicology. Taylor and Francis Ltd., London.
3.	Smart, R. C., Hodgson, E., (Ed.) (2013). Molecular and biochemical toxicology. John Wiley and Sons, Inc.

On-line resources to be used if available as reference material
On-line Resources

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Course Code	PS03CBIC54	Title of the Course	LAB-I
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To learn to determine concentration of blood parameters like glucose, lipid parameters, etc. 2. To learn fundamental Molecular Biology techniques like isolation of DNA, RNA, Restriction digestion, agarose gel electrophoresis of DNA, etc. 3. To learn PCR. 4. To learn RAPD analysis and construction of Phylogenetic tree..

PS03CBIC54 (Lab 1)

1. Determination of serum glucose by GOD/POD method
2. Estimation of total cholesterol, HDL, LDL
3. Demonstration of blood pressure using digital and conventional methods
4. Observation of anatomy slides
5. Comparison of bleeding and clotting time in male and female
6. Determination of Salivary Amylase activity
7. Oxygen saturation measurement using pulse oximeter
8. Measurement of muscle strength
9. Lung capacity measurement using spirometer
10. Isolation of plasmid by alkali lysis method
11. Separation of nucleic acid by Agarose gel electro phoresis
12. Polymerase Chain Reaction
13. Transformation of *E. coli* by suitable plasmid
14. Primer designing for PCR
15. RAPD and phylogenetic tree construction

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Work with clinical samples and carry out analysis.
2.	Carry out molecular analysis of DNA and RNA.
3	Do gene cloning.

References:

1	Thimmaiah S. K. (2012). Standad Methods of Biochemical Analysis. Kalyani Publishes, New Delhi, India.

Course Code	PS03CBIC55	Title of the Course	LAB-II
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To learn to determine enzyme inhibition activity. 2. To learn importance of glutathione in maintaining reducing environment in a cell and estimate glutathione as well as ROS levels. 3. To learn carry out DNA integrity study.

PS03CBIC55 (Lab 2)

1. Trypsin inhibitory activity
2. Effect of toxin on tissue protein levels
3. Estimation of glutathione
4. Estimation of reactive oxygen species
5. Effect of ROS on integrity of DNA by agarose gel electrophoresis
6. Micronuclei test
7. Water analysis: TSS, TDS, Alkalinity, Chlorinity.

PS03CBIC54 (Lab 2 B)

Practicals related to elective papers.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Design experiments for toxicity testing.
2.	Carry out molecular analysis of effects of toxic substances on cellular biomolecules.

References:

1	Thimmaiah S. K. (2012). Standad Methods of Biochemical Analysis. Kalyani Publishes, New Delhi, India.

(Master of Science) (Biochemistry)
(M.Sc.) (Biochemistry) Semester (III)

Course Code	PS03EBIC51	Title of the Course	Biomanufacturing principles and practices
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1.To make the students understand the concept, development and use of SOPs in Biomanufacturing 2. To impart knowledge on essential quality parameters and their measurement in Biomanufacturing. 3. Familiarize the students to the basic needs of a Biotechnology industry

Course Content		
Unit	Description	Weightage* (%)
1.	Overview and design of biomanufacturing, quality by design approach, technical considerations, phases and scale up: life cycle of manufacturing, raw material considerations, compliance and quality in biomanufacturing, lean biomanufacturing; Standard manufacturing operating procedures of biotechnology, quality control of protein production, and final fill and finish of product; Case studies to be included at least: therapeutic proteins, monoclonal antibodies, human vaccines.	25%
2.	Introduction to quality system, main elements of a quality system; Essential of quality system; Practical implementation of a quality system; Structure of quality manual, correlation between GMP requirements (WHO) and ISO 9001:2000.	20%
3.	Personnel: Principles of human resource management, duties of senior management, organizational structures, qualification and profiles requirement. Premises: Official requirements, material & personnel flow and layout, air cleanliness classes and grades, construction elements, barrier systems, isolators and safety cabinets, building services, heating ventilation air conditioning (HVAC), process gases, qualification of premises and HVAC systems, pharma monitoring of HVAC systems, particle monitoring.; Process Validation: Official requirements, Validation - a key element of quality management, validation planning and procedure, validation documentation, process validation and product lifecycle ; Cleaning	30%

	Validation: Official requirements, how to validate cleaning procedures.	
4.	Production: Sanitation, GMP in production process, sterilisation processes, aseptic processing, freeze-drying, testing for sterility, testing for endotoxins, testing for leakage and for particles, microbiological monitoring, packaging materials, packaging process. Information: National bodies and pharmaceutical associations; Pharmacopeia; EU directives and guidelines, USA: CFR and FDA guidelines, ICH-guidelines, PIC/S guidelines, GMP of other regions, WHO guidelines.	25%

Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand fundamental operations, procedures and rules of Industrial manufacturing with special reference to Biological products.
2.	Learn the basic components of an industry, GMP and SOP along with industry standards of testing, sterilization and packing

3.	Become familiar with industry certification process, it's significance and relevance
4.	Learn various guidelines and regulations for biomanufacturing in detail

Suggested References:	
Sr. No.	References
1.	Introduction to Biomanufacturing, by Northeast Biomanufacturing Center and collaboration, 2012.
2.	Introduction to Biomanufacturing, by Mark Witcher. In Encyclopedia of Industrial Biotechnology.
…	Good Manufacturing Practices for Pharmaceuticals (e-resource): A Plan for Total Quality Control. Sidney Willig and James Stoker
	Biotechnology Operations: Principles and Practices, by John M. Centanni, Michael J. Roy; CRC press
	GMP Manual; Publisher Maas & Peither America, Inc. GMP Publishing.

On-line resources to be used if available as reference material
On-line Resources

(Master of Science) (Biochemistry)
(M.Sc.) (Biochemistry) Semester (III)

Course Code	PS03EBIC52	Title of the Course	Plant Biochemistry
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	Students should be able to understand: 1. physiology and biochemistry of plants. 2. regulation of growth of the plants 3. plant defence against the pathogens and herbivores.

Course Content		
Unit	Description	Weightage* (%)
1.	Introduction - The aim and scope of Plant Biochemistry Structure and biochemical aspects of specialized plant cell organelles – cell plate, primary and secondary cell walls, plasmodesmata, importance of vacuoles, characteristics of meristematic cells. Water relations of plants – role of water, absorption, adsorption, conduction and transpiration, guttation, water balance and stress. Mineral metabolism – role of different minerals absorption and translocation of inorganic and organic substances.	25
2.	Photosynthesis - Light and pigments; Light dependent reactions of Photosynthesis; Carbon metabolism – The Photosynthetic Carbon Reduction (PCR) cycle; Activation and regulation of the PCR cycle, The C4 syndrome, Crustacean Acid Metabolism (CAM), Regulation of C4 photosynthesis and CAM; Translocation and distribution of photo assimilates, Photorespiration, Factors affecting the rate of photosynthesis. Respiration - Organization of mitochondrial electron transport system in plants, cyanide resistant pathway and alternative oxidase, its role in regulation of mitochondrial electron transport. Transport of metabolites across mitochondrial Membrane. Regulation of	25

	pentose phosphate pathway and its significance. Gluconeogenesis. Anaerobic respiration.	
3.	Plant Hormones - Growth regulating substances and their mode of action. Role of auxins, gibberelic acid, abscisic acid, cytokinins and brassinosteriods in the regulatory cell extension, germination, growth and development. Signal transduction and gene expression. Application of growth regulators in plant tissue culture	25
4.	Secondary metabolism - Special features, formation and functions of phenolic acids, tannins, lignins, flavonoid pigments, surface waxes, cutin and suberin – the plant protective waxes, terpenes. Signaling molecules in defense system in plants (ethylene, Jasmonic acid and Salicylic acid), Pathogenesis Related (PR) Proteins. Nitrogen assimilation and Biological nitrogen fixation.	25

Teaching-Learning Methodology	Topics will be taught and discussed in interactive sessions using conventional black board and chalk as well as ICT tools such as power point presentations and videos. Practical sessions will be conducted in a suitably equipped laboratory either individually or in groups depending on the nature of exercise as well as availability of infrastructure. Course materials will be provided from primary and secondary sources of information.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to

1.	Students will have clear understanding of water relations and mineral nutrition of plants.
2.	Students will have clear understanding of photosynthesis and carbon metabolism of plants.
3.	The role growth regulators in plant growth and their application in plant tissue culture will be clearly understood
4.	Plant defence and the role secondary metabolism will be made clear

Suggested References:	
Sr. No.	References
1.	**Taiz**, L., & **Zeiger**, E. (1991). Plant physiology. Redwood City, Calif: Benjamin/Cummings Pub. Co. Chicago (Author-Date, 15th ed.).
2.	W. G. **Hopkins,** Introduction to **Plant Physiology**. 2nd edn, John Wiley & Sons Ltd, ISBN 0 -471- 19281- 3.
3.	Hans-**Walter** Heldt Birgit Piechulla; **Plant Biochemistry** - 5th Edition - ISBN: 9780128186312

On-line resources to be used if available as reference material
On-line Resources
Related review articles and research papers

Master of Science in Biochemistry
M.Sc. Biochemistry Semester III

Course Code	PS03EBIC53	Title of the Course	Bioinformatics
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	1. To get knowledge and awareness of the basic principles and concepts of biology, computer science and mathematics 2. To explore existing software effectively to extract information from large databases and to use this information in computer modelling 3. To get problem-solving skills, including the ability to develop new algorithms and analysis methods. 4. To train student for understanding of the intersection of life and information sciences, the core of shared concepts, language and skills the ability to speak the language of structure-function relationships, information theory, gene expression, and database queries.

Course Content		
Unit	Description	Weightage* (%)
1.	❖ **Introduction to Bioinformatics:** ▪ Introduction and Bioinformatics Resources: ▪ Knowledge of various databases and bioinformatics tools available at these resources, the major content of the databases, Literature databases: ▪ Describe about various approaches in genome sequencing and NGS ▪ Overview of Sequence trace files (or chomatograms) raw data output from sequencer machines, Assembling and storing of the sequencer data files. ▪ Nucleic acid sequence databases: GenBank, EMBL, DDBJ ▪ Protein sequence databases: SWISS-PROT, TrEMBL, PIR, PDB, SCOP, CATH ▪ Genome Databases at NCBI, EBI, TIGR, SANGER ▪ Other Databases of Patterns/Motifs/System Biology (Gene and protein network database and resources) ❖ **Sequence analysis:** ▪ Various file formats for bio-molecular sequences: GENBANK, FASTA, GCG, MSF, NBRF-PIR etc. ▪ Basic concepts of sequence similarity, identity and homology, Definitions of homologues, orthologues, paralogues, xenologus. ▪ Scoring matrices: basic concept of a scoring matrix, PAM and BLOSUM series.	25%

	▪ Database Searches: what are sequence-based database searches, BLAST and FASTA algorithms, various versions of basic BLAST and FASTA. ▪ Pairwise and Multiple sequence alignments: basic concepts of sequence alignment, Needleman & Wuncsh, Smith & Waterman algorithms for pairwise alignments, Progressive and hierarchical algorithms for MSA. ▪ Use of pairwise alignments and Multiple sequence alignment for analysis of Nucleic acid and protein sequences and interpretation of results.	
2.	❖ **Gene prediction:** ▪ Gene structure in Prokaryotes and Eukaryotes, Gene prediction methods: Neural Networks, Pattern Discrimination methods, Signal sites Predictions, Evaluation of Gene Prediction methods. ❖ **Computational RNA Structure analysis:** ▪ Secondary and tertiary structure of RNA. Various algorithms of RNA folding and their analysis. Energy minimization in RNA folding. RNA sequence alignment based on secondary structure and its applications in functional genomics and phylogeny. ❖ **Transcriptomics:** ▪ Complete transcript cataloguing and gene discovery sequencing ▪ Microarray based technologies and computation based technologies	25%
3.	❖ **Genomics:** ▪ Concepts and tools for genomics and comparative Genomics ▪ Ancient conserved regions ▪ Horizontal gene transfer ▪ Functional classification of genes ▪ Gene order (synteny) is conserved on chromosomes of related organisms. ▪ Prediction of gene function based on a composite analysis. ▪ Functional genomics. ▪ Putting together all of the information into a genome database. ❖ **Phylogenetic analysis:** ▪ Definition and description of phylogenetic trees and various types of trees, Molecular basis of evolution, Method of construction of Phylogenetic trees: Distance based method (UPGMA, NJ), Character Based Method (Maximum Parsimony and Maximum Likelihood method).	25%
4.	❖ **Proteomics and Protein Computational Biology:** ▪ Tools for proteomics: Acquisition of protein structure	25%

	information, databases and applications. ▪ Structural classification of proteins, Protein structure analysis structure alignment and comparison, ▪ Secondary structure and evaluation: algorithms of Chou Fasman, GOR methods. ▪ Tertiary Structure: Basic principles and protocols, Methods to study 3D structure; Prediction of specialized structures. Protein folding, Protein modelling, Method of protein structure evaluation; Active site prediction. ▪ Protein-protein and protein-ligand interaction/Docking; Drug Designing, QSAR studies. ❖ **Protein structure comparison and classification:** ▪ Classes, Folds, Motif, Domain; ▪ Purpose of structure comparison ▪ Algorithms such as FSSP, VAST and DALI. ▪ Principles of protein folding and methods to study protein folding.	

Teaching-Learning Methodology	Online / Offline / Presentation / Videos	

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	To get introduced to the basic concepts of Bioinformatics and its significance in Biological data analysis.
2.	To get introduced to the basics and advance of sequence alignment and analysis.
3.	To get overview about biological macromolecular structures and structure prediction methods.
4.	To understand the structural organisation, structural properties and various techniques employed in the structure determination of Biological macromolecules – DNA &

	Protein.
5.	To get exposed to computational methods, tools and algorithms employed for Biological Data Interpretation.
6.	To have hands on training on various computational tools and techniques employed in Biological sequence analysis.
7.	To get exposed to various tools and methodologies used in multiple sequence alignment, phylogenetic analysis and genetic diversity analysis observed in biological sequences.
8.	To impart knowledge on chemical databases, various advanced techniques and tools like docking, QSAR studies etc employed in computational drug discovery.
9.	To get knowledge about various approaches in genome sequencing and NGS.

Suggested References:

Sr. No.	References
1.	Bioinformatics: A Beginners Guide, Clavarie and Notredame
2.	Bioinformatics: David Mount
3.	Bioinformatics: Rastogi
4.	Introduction to Bioinformatics: Arthur M. Lesk
5.	Bioinformatics: Principles and applications, Ghosh and Mallick
6.	Bioinformatics: Genes, Proteins and Computer, C A Orengo
7.	Protein Structure Prediction: Methods and Protocols, Webster, David (Southern Cross Molecular Ltd., Bath, UK)

On-line resources to be used if available as reference material

On-line Resources

Nucleotide Sequence Databases (the principal ones)

- NCBI - National Center for Biotechnology Information
- EBI - European Bioinformatics Institute
- DDBJ - DNA Data Bank of Japan

Protein Sequence Databases

- SWISS-PROT & TrEMBL - Protein sequence database and computer annotated supplement
- **UniProt** - UniProt (Universal Protein Resource) is the world's most comprehensive catalog of information on proteins. It is a central repository of protein sequence and function created by joining the information contained in Swiss-Prot, TrEMBL, and PIR.
- PIR - Protein Information Resource
- MIPS - Munich Information centre for Protein Sequences
- HUPO - HUman Proteome Organization

Database Searching by Sequence Similarity

- BLAST @ NCBI
- PSI-BLAST @ NCBI
- FASTA @ EBI
- BLAT Jim Kent's Blat is just superb in terms of speed and the integrated view you get for viewing the results

Sequence Alignment

- USC Sequence Alignment Server - align 2 sequences with all possible varieties of dynamic programming
- T-COFFEE - multiple sequence alignment
- ClustalW @ EBI - multiple sequence alignment
- MSA 2.1 - optimal multiple sequence alignment using the Carrillo-Lipman method
- BOXSHADE - pretty printing and shading of multiple alignments
- Splign - Splign is a utility for computing cDNA-to-Genomic, or spliced sequence alignments. At the heart of the program is a global alignment algorithm that specifically accounts for introns and splice signals.
- Spidey - an mRNA-to-genomic alignment program

Protein Domains: Databases and Search Tools

- InterPro - integration of Pfam, PRINTS, PROSITE, SWISS-PROT + TrEMBL
- PROSITE - database of protein families and domains
- Pfam - alignments and hidden Markov models covering many common protein domains
- SMART - analysis of domains in proteins
- ProDom - protein domain database
- PRINTS Database - groups of conserved motifs used to characterise protein families
- Blocks - multiply aligned ungapped segments corresponding to the most highly conserved regions of proteins

Protein 3D Structure

- PDB - protein 3D structure database
- RasMol / Protein Explorer - molecule 3D structure viewers
- SCOP - Structural Classification Of Proteins
- UCL BSM CATH classification
- The DALI Domain Database
- FSSP - fold classification based on structure-structure alignment of proteins
- SWISS-MODEL - homology modeling server
- Structure Prediction Meta-server

- K2 - protein structure alignment
- DALI - 3D structure alignment server
- DSSP - defines secondary structure and solvent exposure from 3D coordinates
- HSSP Database - Homology-derived Secondary Structure of Proteins
- PredictProtein & PHD - predict secondary structure, solvent accessibility, transmembrane helices, and other stuff
- Jpred2 - protein secondary structure prediction
- PSIpred (& MEMSAT & GenTHREADER) - protein secondary structure prediction (& transmembrane helix prediction & tertiary structure prediction by threading)

Phylogeny & Taxonomy

- The Tree of Life
- Species 2000 - index of the world's known species
- TreeBASE - a database of phylogenetic knowledge
- PHYLIP - package of programs for inferring phylogenies
- TreeView - user friendly tree displaying for Macs & Windows

Gene Prediction

- Genscan - eukaryotes
- GeneMark
- Genie - eukaryotes
- GLIMMER - prokaryotes
- tRNAscan - SE 1.1 - search for tRNA genes in genomic sequence
- GFF (General Feature Format) Specification - a standard format for genomic sequence annotation

Metabolic, Gene Regulatory & Signal Transduction Network Databases

- KEGG - Kyoto Encyclopedia of Genes and Genomes
- BioCarta
- **DAVID** - **D**atabase for **A**nnotation, **V**isualization and **I**ntegrated **D**iscovery - A useful server to for annotating microarray and other genetic data.
- stke - Signal Transduction Knowledge Environment
- BIND - Biomolecular Interaction Network Database
- EcoCyc
- WIT
- **PathGuide** A very useful collection of resources dealing primarily with pathways
- SPAD - Signaling Pathway Database
- CSNDB - Cell Signalling Networks Database
- PathDB
- Transpath
- DIP - Database of Interacting Proteins
- PFBP - Protein Function and Biochemical Networks

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