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. Biotechnology Semester: III

Programme Outcome (PO) - For M.Sc. Biotechnology Programme	On successful completion of the Masters in Biotechnology course, the student will be able to: 1. Demonstrate an ability for in depth analytical and critical thinking to identify and solve problems related to Biotechnology in industry, medicine and Agriculture 2. Comprehend and integrate theoretical and practical skills 3. Demonstrate mastery in handling sophisticated laboratory equipment and their appropriate applications. 4. Become a professional suitable to be employed in industry as well as academic institutions 5. Understand professional and ethical responsibility.
Programme Specific Outcome (PSO) - For MSc Biotechnology Semester - III	1. Students will be able to demonstrate and apply their knowledge of cell structure and functions both at organelle and molecular level and solve the problems related to the field of biotechnology 2. Students will be exposed to basic physiological and metabolic processes and their relevance in Biotechnology

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
Core Course	PS03CBIT51	Fermentation technology	T	4	3	30	70	100
	PS03CBIT52	Genetic Engineering	T	4	3	30	70	100
	PS03CBIT53	Plant Biotechnology	T	4	3	30	70	100
	PS03CBIT54	Practicals	P	4	3	30	70	100
	PS03CBIT55	Practicals	P	4	3	30	70	100
Elective Course (Any One)	PS03EBIT51	Biomanufacturing principles and practices	T	4	3	30	70	100
	PS03EBIT52	Toxicology	T	4	3	30	70	100
	PS03EBIT53	Bioinformatics	T	4	3	30	70	100

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

Course Code	PS03CBIT51	Title of the Course	Fermentation technology
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To understanding of upstream and downstream processing 2. To understand Isolation, preservation, improvement, handling of organisms and optimization of media 3. To understand various types of small and large scale equipment, controls and concept of scale up 4. To understand basic concepts of growth, cultivation and product recovery 5. To understand biochemistry for overproduction of various industrially important microbial metabolites. 6. To learn about fermentation processes for various primary metabolites, secondary metabolites, microbial biomass and biotransformations.

Course Content		
Unit	Description	Weightage* (%)
1.	Introduction to bioprocess technology, Isolation, preservation and improvement of industrially important organisms. Substrates for fermentation processes. Medium optimization Bioreactor design: Laboratory, pilot and large scale reactors. Plug flow reactors, enzyme reactors. Inoculum development and aseptic inoculation Sterilization of media and air	25
2.	Kinetics of growth and substrate utilization in batch, fed batch and continuous systems. Mass transfer of oxygen: Agitation and aeration, Determination of KLa, factors affecting KLa, fluid rheology. Control of process parameters: Instrumentation for monitoring bioreactor and fermentation processes, Sensors, Controllers, fermentation control systems and architecture, Incubation and sequence control, advanced control. Downstream processing: Methods of Cell separation, Disruption and product purification. Fermentation economics	25
3.	Fermentative production and applications of primary metabolites: Citric acid, L Glutamic acid, L Lysine ,Vitamins B12 and Vitamin B2 Industrially important microbial enzymes: Types, mode of action and	25

	applications of microbial amylases and proteases Microbial production of therapeutically important secondary metabolites:. Penicillin , Ergot alkaloids	
4.	Biotransformations of steroids: Hydroxylations and dehydrogenations, Sterol biotransformations. Production and applications of microbial exopolysaccharides: Classification, biological functions, Structure and Biosynthesis of Xanthan and Alginate, Factors affecting fermentative production of exopolysaccharides and recovery. Technology of Beer brewing: Single cell proteins: Production and applications. Production of bioplastics	25
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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.	Appreciate the concept and scope of Bioprocess upstream and downstream processing and the economics of industrial processes
2.	Handle and work with Microbial cultures, especially its screening, maintenance,

	preservation and cultivation
3.	Get trained and work with industrial processes for large scale sterilization, inoculation, production and product recovery
4.	Develop ability to understand various strategies for enhanced fermentative production of various primary and secondary metabolites of microorganisms.

Suggested References:

Sr. No.	References
1.	Principles of Fermentation Technology : Whitekar & Stanbury
2.	Comprehensive Biotechnology : Murray Moo Young
3	Methods in Industrial Microbiology : Sikyta
4	Fermentation Microbiology and Biotechnology, El Mansi and Bryc
5	Microbial technology by Peppler
6	Biotechnology by Rehm and Reid

On-line resources will be provided by teacher from time to time

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

Course Code	PS03CBIT52	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 and microbes; Gene editing and its applications; Metagenomics and Metabolic engineering; Gene therapy; Restriction and regulations for	25%

	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.	Explain different steps involved in gene cloning, different enzymes available and how to choose an enzyme for a particular application in genetic engineering.
2.	Describe salient features of different vectors available, their design and strategies to be applied for cloning and selection of recombinants.
3.	Explain details of preparation of genomic and cDNA libraries as well as discuss various strategies for screening of recombinant clones.
4	Explain the PCR and its variants in detail along with their applications. Students will be able to design PCR primers and reaction parameters.
5	Describe different types of molecular markers and their applications in detail.
6	Explain various DNA sequencing techniques and their applications in detail.
7.	Describe genetic engineering guidelines and regulatory procedures to be followed while

	conducting genetic engineering experiments

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 (Biotechnology)
M.Sc. (Biotechnology) Semester (III)

Course Code	PS03CBIT53	Title of the Course	Plant Biotechnology
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1.To make the students understand the concepts of modern techniques in plant propagation 2.To facilitate the students with knowledge on recent developments in crop improvement 3. To address the pros and cons of GM crops. 4. To facilitate technical and theoretical know how for the application of molecular tools in crop improvement and crop production.

Course Content		
Unit	Description	Weightage* (%)
1.	Cell & tissue culture in plants; in-vitro morphogenesis, organogenesis and embryogenesis; Artificial Seeds, Micro propagation (Clonal propagation); Haploidy; anther and ovule cultures, Embryo cultures; Protoplast isolation, culture and protoplast fusion and somatic hybridization, Cybrids, Somaclonal Variation;; Virus elimination, pathogen indexing; Cryopreservation	25%
2.	Production of secondary metabolites; Sources of plant secondary metabolites;criteria for cell selection, factors affecting the culture of cells; different bioreactorsand their use in secondary metabolite production; biochemical pathways for theproduction of different secondary metabolites; and biotransformation.	25%
3.	Methods for genetic transformation and transgenic plants production through*Agrobacterim tumefaciens* and *A. rhizogenes*; Gene transfer methods in plants; PEG mediated, particle bombardment, Molecular markers and their importance in plant breeding, Marker Assisted Selection (MAS).	25%
4.	Commercially grown Transgenic plants: BT crops, Golden rice, transgenic crops for herbicide tolerance, disease and abiotic stress resistance**.** Indian laws and regularions for the release and cultivation of transgenic plants. Biotechnology and intellectual property rights (IPR); Plant geneticresources GATT & TRIPS; Patent for higher plant genes and DNA sequence	25%

Teaching-Learning	Topics will be taught and discussed in interactive sessions using

Methodology	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 the significance of plant biotechnology for improving crop productivity
2.	They can apply this knowledge to establish clonal propagation methods for important as well as endangered plants
3.	Students will also understand the pros and cons of transgenic plants as well as intellectual property management and handling of GMOs.
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Suggested References:	
Sr. No.	References
1.	Plant Biotechnology: The genetic manipulation of plants – Adrial Slater, Nigel W. Scott and Mark R. Fowler
2.	An Introduction to Plant Biotechnology: H.S. Chawla
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On-line resources to be used if available as reference material
On-line Resources

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Course Code	PS03CBIT54	Title of the Course	LAB-I
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To learn to isolate bacterial cells and carry out fermentation experiments. 2. To learn Molecular Biology techniques like isolation of Plasmids, Restriction digestion, agarose gel electrophoresis etc. 3. To learn RAPD analysis.

PS03CBIT54 (Lab 1)

1. Cellulase production by Solid State Fermentation (SSF)

a. Endoglucanase assay
b. Filter paper activity
c. Protein estimation by Folin's and Lowry's method
2. Saccharification of agro-waste by cellulose
3. Yoghurt making
4. Isolation of lactic acid bacteria
5. Antimicrobial activity of Lactobacillus strains
6. Screening and isolation of proteolytic bacteria
7. Screening and isolation of Amylase producing bacteria
8. Isolation of plasmid DNA by alkali lysis method and agarose gel electrophoresis
9. Restriction digestion of plasmid DNA
10. Transformation of *E.coli* by a suitable plasmid
11. Elution of DNA from agarose gel
12. RAPD

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 in industrial microbiology laboratory.
2.	Carry out Molecular Biology experiments.
3	Isolate plasmids and modify it.

References:

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

Course Code	PS03CBIT55	Title of the Course	LAB-II
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To learn selection of explants, induction of callus and plant tissue culture technique. 2. To learn organogenesis and embryogenesis. 3. To learn embryo isolation and culture.

PS03CBIT55 (Lab 2 A)

1. Preparation of MS medium and Hormone stocks
2. Callus induction from Tobacco leaf/carrot explants (Medium preparation, surface sterilization, inoculation, observation and interpretation of results)
3. Micropropagation of banana
4. Shoot induction through organogenesis from tobacco callus
5. Somatic embryogenesis induction from carrot cell suspension
6. Tobacco anther culture for haploid plant production
7. Culture of zygotic embryos (embryo isolation and culture)
8. Synthetic seed preparation.

PS03CBIT55 (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.	Carry out fundamental plant tissue culture experiments.
2.	Do organogenesis and embryogenesis from suitable materials.
3	Culture zygotic embryos.

References:

1	J. Reinert and M. M. Yeoma. Plant cell and tissue culture: A laboratory manual. Springer

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

Course Code	PS03EBIT51	Title of the Course	Biomanufacturing principles and practices
Total Credits of the Course	04	Hours per Week	03

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.
3.	Good Manufacturing Practices for Pharmaceuticals (e-resource): A Plan for Total Quality Control. Sidney Willig and James Stoker
4.	Biotechnology Operations: Principles and Practices, by John M. Centanni, Michael J. Roy; CRC press
5.	GMP Manual; Publisher Maas & Peither America, Inc. GMP Publishing.

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

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

Course Code	PS03EBIT52	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 toxicity 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 toxicants

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-thiocarbamates, Herbicides:2,4 D, Atrazine; Food additives:	25

	Preservatives, 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 learnerwill 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'stoxicology : 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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Master of Science (Biotechnology)
M.Sc. (Biotechnology) Semester (III)

Course Code	PS03EBIT53	Title of the Course	Bioinformatics
Total Credits of the Course	04	Hours per Week	04

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. ▪ Database Searches: what are sequence-based database searches,	25%

	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 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.	25%

	▪ 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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