SANT GADGE BABA AMRAVATI UNIVERSITY, AMRAVATI

M. Sc. Biotechnology (CBCS)

Semester III (CBCS)

Sr. No.	Course/ Credits	Subject Code	Course Title	Hours/ Week	Credit
1.	DSC-X	3BTB-DSC-X	Bioprocess Engineering & Technology	3	3
2.	DSC-XI	3BTB-DSC-XI	Downstream Processing	1	1
3.	DSC-XII	3BTB-DSC-XII	Bioinformatics	3	3
4.	DSC-XIII	3BTB-DSC-XIII	Emerging Technologies	3	3
5.	DSC-XIV	3BTB-DSC-XIV	Environmental Biotechnology	3	3
6.	AEC-III	3BTB-AEC-III	Critical Analysis of Classical Papers	2	2
7.	Seminar	3BTB-SEM	Seminar	2	2
8.	Laboratory VIII	3BTB-LC-VIII	Bioprocess Engineering & Technology and Down Stream Processing	6	3
9.	Laboratory IX	3BTB-LC-IX	Environmental Biotechnology	6	3
10.	Laboratory X	3BTB-LC-X	Bioinformatics and Emerging Technologies	6	3
11.	Project	3BTB-P	Project (Planning, Review, Presentation)	2	1
12.	#Internship/ Field Work/Work Experience @		Internship/ Field Work/Work Experience @		
13.	Open Elective /GIC/ Open Skill/MOOC *		Open Elective /GIC/ Open Skill/MOOC *		
			Total	37	27

Students may complete their internship /Field work/ work experience in First or Second or Third semester Of MSc (Biotechnology) according to their convenience, @ denotes Non Examination Credit

Note: Internship/ Apprenticeship/ field work/ Work experience (during vacations of Semester I to Semester III) For duration of minimum 60 hours to Maximum 90 hours mandatory to all students, me to complete during vacations of Semester I to Semester III. This will carry two credits for learning of 60 hours or 3 Credits for learning of 90 hours. The credits and grades will be reflected in Semester 4 credit grade report.

OEC (Optional) can be studied during semester I to IV

Semester IV (CBCS)

S.No.	Course/ Credits	Subject Code	Course Title	Hours/Week	Credit
1.	DSC-XV	4BTB-DSC-XV	Animal Cell Science and Technology	3	3
2.	DSC-XVI	4BTB-DSC-XVI	Vaccine	1	1
3.	DSC-XVII	4BTB-DSC-XVII	Industrial Biotechnology	3	3
4.	DSE-II	4BTB-DSE- A, B, C, D, E, F	Elective	2	2
5.	Laboratory X	4BTB-LC-X	Animal Cell Science & Technology	6	3
6.	Laboratory XI	4BTB-LC-XI	Industrial Biotechnology	6	3
7.	Project	4BTB-P	Project - Laboratory Work	12	6
8.	#Internship/ Field Work/Work Experience @		Internship/ Field Work/Work Experience @		
9.	SEC-II		Introduction to programming using 'Python'	2	2
10.	Open Elective /GIC/ Open Skill/MOOC *		Open Elective /GIC/ Open Skill/MOOC *		
				35	23

DSE (Discipline Specific Elective)

4BTB-DSE-A Cancer Biology; 4BTB-DSE-B Molecular Basis of Drug Discovery; 4BTB-DSE-C Clinical Trial & Research; 4BTB-DSE-D Phyto secondary Metabolites and its Bioactivity; 4BTB-DSE-E Nanobiotechnology; 4BTB-DSE-F DNA Fingerprinting

Students may complete their internship /Field work/ work experience in First or Second or Third semester Of MSc (Biotechnology) according to their convenience, @ denotes Non-Examination Credit

Note: Internship/ Apprenticeship/ field work/ Work experience (during vacations of Semester I to Semester III) For duration of minimum 60 hours to Maximum 90 hours mandatory to all students, me to complete during vacations of Semester I to Semester III. This will carry two credits for learning of 60 hours or 3 Credits for learning of 90 hours. Is credits and grades will be reflected in Semester 4 credit grade report.

OEC (Optional) can be studied during semester I to IV

Part B

Syllabus Prescribed for M.Sc. II Year PG Programme

Programme: M.Sc. Biotechnology

Semester III

Code of the Course/Subject	Title of the Course/Subject	Total Number of Period
3BTB-DSC-X	**Bioprocess Engineering & Technology**	**45 hrs**

Cos: The objectives of this course are to educate students about the fundamental concepts of bioprocess technology and its related applications, thus preparing them to meet the challenges of the new and emerging areas of biotechnology industry.

Students should be able to:

- Appreciate relevance of microorganisms from industrial context;
- Carry out stoichiometric calculations and specify models of their growth;
- Give an account of design and operations of various fermenters;
- Present unit operations together with the fundamental principles for basic methods in production technique for bio-based products;
- Calculate yield and production rates in a biological production process, and also interpret data;
- Calculate the need for oxygen and oxygen transfer;
- Critically analyze any bioprocess from market point of view;
- Give an account of important microbial/enzymatic industrial processes in food and fuel industry.

Unit	Content
Unit I	**Basic principles of biochemical engineering-**Isolation, screening and maintenance of industrially important microbes; microbial growth and death kinetics (an example from each group, particularly with reference to industrially useful microorganisms); strain improvement for increased yield and other desirable characteristics. **Stoichiometry and models of microbial growth-**Elemental balance equations; metabolic coupling – ATP and NAD+; yield coefficients; unstructured models of microbial growth; structured models of microbial growth.
Unit II	**Bioreactor design and analysis-**Batch and continuous fermenters; modifying batch and continuous reactors: chemostat with recycle, multistage chemostat systems, fed-batch operations; conventional fermentation v/s biotransformation; immobilized cell systems; large scale animal and plant cell cultivation; fermentation economics; upstream processing: media formulation and optimization; sterilization; aeration, agitation, mass and heat transfer in bioprocess; scale up and scale down; measurement and control of bioprocess parameters.
Unit III	**Fermentation economics-**Isolation of micro-organisms of potential industrial interest; strain improvement; market analysis; equipment and plant costs; media; sterilization, heating and cooling; aeration and agitation; bath-process cycle times and continuous cultures; recovery costs; water usage and recycling; effluent treatment and disposal.

Unit IV	**Applications of enzyme technology in food processing-**Mechanism of enzyme function and reactions in process techniques; enzymatic bioconversions e.g. starch and sugar conversion processes; high-fructose corn syrup; interesterified fat; hydrolyzed protein etc. and their downstream processing; baking by amylases, deoxygenation and desugaring by glucoses oxidase, beer mashing and chill proofing; cheese making by proteases and various other enzyme catalytic actions in food processing.
Unit V	**Applications of microbial technology in food process operations and production, biofuels and biorefinery-**Fermented foods and beverages; food ingredients and additives prepared by fermentation and their purification; fermentation as a method of preparing and preserving foods; microbes and their use in pickling, producing colours and flavours, alcoholic beverages and other products; process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products; bacteriocins from lactic acid bacteria – production and applications in food preservation; biofuels and biorefinery

Course Material/Learning Resources :

1. Shuler, M. L., & Kargi, F. (2002). Bioprocess Engineering: Basic Concepts. Upper Saddle River, NJ: Prentice Hall.

2. Stanbury, P. F., & Whitaker, A. (2010). Principles of Fermentation Technology. Oxford: Pergamon Press.

3. Blanch, H. W., & Clark, D. S. (1997). Biochemical Engineering. New York: M. Dekker.

4. Bailey, J. E., & Ollis, D. F. (1986). Biochemical Engineering Fundamentals. New York: McGraw-Hill.

5. El-Mansi, M., & Bryce, C. F. (2007). Fermentation Microbiology and Biotechnology. Boca Raton: CRC/Taylor & Francis.

6. Doelle HW, Mitchell DA and Rolz CE.Ed. (1992). Solid Substrate Cultivation. Elsevier Applied Science, London, 1992.

5. Rao DG (2005). Introduction to Biochemical Engineering by Tata McGraw-Hill Pub Co Ltd., New Delhi.

6. Peppler HJ and Perlman D (2004). Microbial Technology: Fermentation Technology (2nd Edition) Vol. I & II, by. Academic Press, NY, USA.

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Syllabus Prescribed for M.Sc. II Year PG Programme

Programme: M.Sc. Biotechnology

Semester III

Code of the Course/Subject	Title of the Course/Subject	Total Number of Period
3BTB-DSC-XI	**Downstream Processing**	**15 hrs**

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The objective of this course is to provide an overview of various aspects of recovery and processing of biological products

Students should be able to identify and design relevant unit operations for recovery of a biological product

Unit	Content
Unit I	**Biomass Removal-**Characteristics of biological materials: pretreatment methods; Separation of cell mass: centrifugation, sedimentation, flocculation and filtration; Continuous operation. Cell disruption-Mechanical approaches: son ication, bead mills, homogenizers; non-mechanical approaches: freeze/thaw, osmotic shock, chemical lysis, enzymatic lysis; measurement of cell disruption.
Unit II	**Membrane Process-**Filtration theory; Micro and ultrafiltration; Reverse osmosis; dialysis; electrodialysis, diafiltration; pervaporation; perstraction; Multistage and continuous operation.
Unit III	**Adsorption and Chromatography-**Adsorption equilibrium, Van Deemter equation; Chromatography: size, charge, polarity, shape, hydrophobic interactions; Biological affinity; Process configurations (packed bed, expanded bed, simulated moving beds)
Unit IV	**Concentration steps-**Solvent extraction: phase equilibrium and distribution, counter-current operation, dissociative extraction, multiple stage analysis; Reciprocating-plate and centrifugal extractors; Reverse micellar extraction; Aqueous two phase, Supercritical fluid extraction. Precipitation: effect of size and charge, solvent effects, ionic strength effects, precipitate growth and aging models. Crystallization: nucleation and growth aspects; Drying: solvent removal aspects, dryers (vacuum, freeze, spray); Scale up aspects.
Unit V	**Product Characterization** Biophysical characterization, chemical characterization, modern spectroscopy, QbD, stability Bioassays: Cell based assay, receptor mediated assay, in vivo evaluation, immunogenicity

Course Material/Learning Resources :

1. Stanbury, P. F., & Whitaker, A. (2010). Principles of Fermentation Technology. Oxford: Pergamon Press.

2. Blanch, H. W., & Clark, D. S. (1997). Biochemical Engineering. New York: M. Dekker.

3. Bailey, J. E., & Ollis, D. F. (1986). Biochemical Engineering Fundamentals. New York: McGraw-Hill.

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Programme: M.Sc. Biotechnology

Semester III

Code of the Course/Subject	Title of the Course/Subject	Total Number of Period
3BTB-DSC-XII	**Bioinformatics**	**45 hrs**

The objectives of this course are to provide theory and practical experience of the use of common computational tools and databases which facilitate investigation of molecular biology and evolution-related concepts.

Develop an understanding of basic theory of these computational tools;

• Gain working knowledge of these computational tools and methods;

• Appreciate their relevance for investigating specific contemporary biological questions;

• Critically analyse and interpret results of their study.

Unit	Content
Unit I	**Introduction to computational biology basics and biological databases-**Computers in biology and medicine; Overview of biological databases, nucleic acid & protein databases, primary, secondary, functional, composite, structural classification database, Sequence formats & storage, Access databases, Extract and create sub databases, limitations of existing databases.
Unit II	**Pairwise and multiple sequence alignments-**Local alignment, Global alignment, Scoring matrices - PAM, BLOSUM, Gaps and penalties, Dot plots. Heuristic approach: BLAST, FASTA. Building Profiles, Profile based functional identification
Unit III	**Genome Analysis-**Polymorphisms in DNA sequence, Introduction to Next Generation Sequencing technologies, Whole Genome Assembly and challenges, Sequencing and analysis of large genomes, Gene prediction, Functional annotation, Comparative genomics, Probabilistic functional gene networks, Human genome project, Genomics and crop improvement. Study available GWAS, ENCODE, HUGO projects, extract and build sub databases; Visualization tools including Artemis and Vista for genome comparison; Functional genomics case studies
Unit IV	**Structure visualization-**Retrieving and drawing structures, Macromolecule viewing platforms, Structure validation and correction, Structure optimization, Analysis of ligand-protein interactions; Tools such as PyMol or VMD
Unit V	**Structure-based drug development-**Molecular docking: Types and principles, Semi-flexible docking, Flexible docking; Ligand and protein preparation, Macromolecule and ligand optimization, Ligand conformations, Clustering, Analysis of docking results and validation with known information.

	Extra-precision docking platforms, Use of Small-molecule libraries, Natural compound libraries for virtual high throughput screenings. Ligand-based drug development-Quantitative structure activity relationships; Introduction to chemical descriptors like 2D, 3D and Group-based; Radar plots and contribution plots and Activity predictions, Pharmacophore modelling, Pharmacophore-based screenings of compound library, analysis and experimental validation

Recommended Textbooks and References:

1. Mount, D. W. (2001). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Press.

2. Bourne, P. E., & Gu, J. (2009). Structural Bioinformatics. Hoboken, NJ: Wiley-Liss.

3. Lesk, A. M. (2004). Introduction to Protein Science: Architecture, Function, and Genomics. Oxford: Oxford University Press.

4. Campbell, M & Heyer, L. J. (2006), Discovering Genomics, Proteomics and Bioinformatics, Pearson Education.

5. Oprea, T. (2005). Chemoinformatics in Drug Discovery, Volume 23. Wiley Online Library.

6. Gasteiger, J. & Engel,T. (2003), Chemoinformatics: a Textbook, Wiley Online Library

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Semester III

Code of the Course/Subject	Title of the Course/Subject	Total Number of Period
3BTB-DSC-XIII	**Emerging Technologies**	**45 hrs**

This course is broad-based in nature encompassing several new technologies that current experimental researchers are employing to probe complex system biology questions in life-sciences. The objectives of this course are to teach basics of the new principles to students so as to appreciate current-day research tool-kit better.

Students should be to learn history, theoretical basis and basic understanding of latest technologies in area of biotechnology. They should also be able to learn about various applications of these technologies. The students may also learn one application in depth through an assignment and/or seminar.

Unit	Content
Unit I	**Optical Microscopy Methods** **Basic Microscopy:** Light Microscopy: lenses and microscopes, resolution: Rayleigh's Approach, Darkfield; Phase Contrast; Differential Interference Contrast; fluorescence microscopy: optical arrangement, light source; filter sets: excitation filter, dichroic mirror, and barrier, optical layout for image capture; CCD cameras; back illumination, binning; recording color; three CCD elements with dichroic beamsplitters, boosting the signal. **Advanced Microscopy:** Confocal microscope: scanning optical microscope, confocal principle, resolution and point spread function, light source: gas lasers & solid-state, detectors; pixels and voxels; multiphoton microscopy; principles of two-photon fluorescence, advantages of two-photon excitation, tandem scanning (spinning disk) microscopes, Advanced fluorescence techniques: FLIM, FRET, and FCS, Fluorescence Lifetime, Fluorescence Resonant Energy Transfer (FRET), Fluorescence Correlation Spectroscopy (FCS),
Unit II	**Mass Spectroscopy-**Ionization techniques; mass analyzers/overview MS; FT-ICR and Orbitrap, fragmentation of peptides; proteomics, nano LC-MS; Phospho proteomics; interaction proteomics, mass spectroscopy in structural biology; imaging mass spectrometry.
Unit III	**System Biology-**High throughput screens in cellular systems, target identification, validation of experimental methods to generate the omics data, bioinformatics analyses, mathematical modeling and designing testable predictions. **Structure Biology-**X-ray diffraction methods, solution & solid-state NMR, cryo-electron microscopy, small- angle X-ray scattering, Atomic force microscopy.

Unit IV	**Nanobodies-**Introduction to nanobodies, combining nanobody with phage-display method for development of antibody against native proteins, nanobody as a tool for protein structure-function studies, use of nanobodies for molecular imaging, catabolic antibodies using nanobodies
Unit V	**CRISPER CAS-**History of its discovery, elucidation of the mechanism including introduction to all the molecular players, development of applications for *in vivo* genome engineering for genetic studies, promise of the technology as a next generation therapeutic method.

Recommended Textbooks and References:

1. Campbell, I. D. (2012). Biophysical Techniques. Oxford: Oxford University Press.
2. Serdyuk, I. N., Zaccai, N. R., & Zaccai, G. (2007). Methods in Molecular Biophysics: Structure, Dynamics, Function. Cambridge: Cambridge University Press.
3. Phillips, R., Kondev, J., & Theriot, J. (2009). Physical Biology of the Cell. New York: Garland Science.
4. Nelson, P. C., Radosavljević, M., & Bromberg, S. (2004). Biological Physics: Energy, Information, Life. New York: W.H. Freeman.
5. Huang, B., Bates, M., & Zhuang, X. (2009). Super-Resolution Fluorescence Microscopy. Annual Review of Biochemistry, 78(1), 993-1016. doi:10.1146/annurev. biochem.77.061906.092014.
6. Mohanraju, P., Makarova, K. S., Zetsche, B., Zhang, F., Koonin, E. V., & Oost, J. V. (2016). Diverse Evolutionary Roots and Mechanistic Variations of the CRISPR-Cas Systems. Science, 353(6299). doi:10.1126/science.aad5147.
7. 7. Lander, E. (2016). The Heroes of CRISPR. Cell, 164(1-2), 18-28. doi:10.1016/j. cell.2015.12.041.
8. Ledford, H. (2016). The Unsung Heroes of CRISPR. Nature, 535(7612), 342-344. doi:10.1038/535342a.
9. Jinek, M., Chylinski, K., Fonfara, I., Hauer, M., Doudna, J. A., & Charpentier, E. (2012). A Programmable Dual-RNA-Guided DNA Endonuclease in Adaptive Bacterial Immunity. Science, 337(6096), 816-821. doi:10.1126/science.1225829.
10. Hamers-Casterman, C., Atarhouch, T., Muyldermans, S., Robinson, G., Hammers, C., Songa, E. B., Hammers, R. (1993). Naturally Occurring Antibodies Devoid of Light Chains. Nature, 363(6428), 446-448. doi:10.1038/363446a0.
11. Sidhu, S. S., & Koide, S. (2007). Phage Display for Engineering and Analyzing
12. Protein Interaction Interfaces. Current Opinion in Structural Biology, 17(4), 481-487. doi:10.1016/j.sbi.2007.08.007.
13. Steyaert, J., & Kobilka, B. K. (2011). Nanobody Stabilization of G Protein-Coupled Receptor Conformational States. Current Opinion in Structural Biology,
14. 21(4), 567-572. doi:10.1016/j.sbi.2011.06.011.
15. Vincke, C., & Muyldermans, S. (2012). Introduction to Heavy Chain Antibodies and Derived Nanobodies. Single Domain Antibodies, 15-26. doi:10.1007/978-1-61779- 968-6_2.
16. Verheesen, P., & Laeremans, T. (2012). Selection by Phage Display of Single Domain Antibodies Specific to Antigens in their Native Conformation. Single Domain Antibodies, 81-104. doi:10.1007/978-1-61779-968-6_6.
17. Li, J., Xia, L., Su, Y., Liu, H., Xia, X., Lu, Q. Reheman, K. (2012). Molecular Imprint of Enzyme Active Site by Camel Nanobodies. Journal of Biological Chemistry J. Biol. Chem., 287(17), 13713-13721. doi:10.1074/jbc.m111.336370.
18. Sohier, J., Laurent, C., Chevigné, A., Pardon, E., Srinivasan, V., Wernery, U. Galleni,
19. M. (2013). Allosteric Inhibition of VIM Metallo-β-Lactamases by a Camelid Nanobody.

20. Biochemical Journal, 450(3), 477-486. doi:10.1042/bj20121305.
21. Chakravarty, R., Goel, S., & Cai, W. (2014). Nanobody: The “Magic Bullet” for Molecular Imaging? Theranostics, 4(4), 386-398. doi:10.7150/thno.8006.

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Syllabus Prescribed for M.Sc. II Year PG Programme

Programme: M.Sc. Biotechnology

Semester III

Code of the Course/Subject	Title of the Course/Subject	Total Number of Period
3BTB-DSC-XIV	**Environmental Biotechnology**	**45 hrs**

This course aims to introduce fundamentals of Environmental Biotechnology. The course will introduce major groups of microorganisms, tools in biotechnology and their most important environmental applications. The environmental applications of biotechnology will be presented in detail and will be supported by examples from the national and international literature.

On completion of course, students will be able to understand use of basic microbiological, molecular and analytical methods, which are extensively used in environmental biotechnology.

Unit	Content
Unit I	**Introduction to environment;** pollution and its control; pollution indicators; waste management: domestic, industrial, solid and hazardous wastes; strain improvement; Biodiversity and its conservation; Role of microorganisms in geochemical cycles; microbial energy metabolism, microbial growth kinetics and elementary chemostat theory, relevant microbiological processes, microbial ecology
Unit II	**Bioremediation:** Fundamentals, methods and strategies of application (biostimulation, bioaugmentation) – examples, bioremediation of metals (Cr, As, Se, Hg), radionuclides (U, Te), organic pollutants (PAHs, PCBs, Pesticides, TNT etc.), technological aspects of bioremediation (in situ, ex situ).
Unit III	**Application of bacteria and fungi in bioremediation:** White rot fungi vs specialized degrading bacteria: examples, uses and advantages vs disadvantages; Phytoremediation: Fundamentals and description of major methods of application (phytoaccumulation, phytovolatilization, rhizofiltration phytostabilization, Bio control mechanism.
Unit IV	**Environmental forensic:** Introduction and application of Environmental forensic, principle and methods of chemical fingerprinting (crude oil and refined products), forensic techniques in litigation, environmental forensic microscopy and case studies in environmental forensic
Unit V	**Environmental Biotechnology and biofuels:** biogas; bioethanol; biodiesel; biohydrogen; Description of the industrial processes involved, microorganisms and biotechnological interventions for optimization of production; Microbiologically enhanced oil recovery (MEOR); Bioleaching of metals; Production of bioplastics; Production of biosurfactants: bioemulsifiers; Paper production: use of xylanases and white rot fungi.

Recommended Textbooks and References:

1. G. M. Evans and J. C. Furlong (2003), Environmental Biotechnology: Theory and Applications, Wiley Publishers.
2. B. Ritmann and P. L. McCarty, (2000), Environmental Biotechnology: Principle & Applications, 2nd Ed., McGraw Hill Science.
3. Scragg A., (2005) Environmental Biotechnology. Pearson Education Limited.
4. J. S. Devinny, M. A. Deshusses and T. S. Webster, (1998), Biofiltration for Air Pollution Control, CRC Press.
5. H. J. Rehm and G. Reed, (2001), Biotechnology – A Multi-volume Comprehensive Treatise, Vol. 11, 2nd Ed., VCH Publishers Inc.
6. H. S. Peavy, D. R. Rowe and G. Tchobanoglous, (2013), Environmental Engineering, McGraw-Hill Inc.

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Programme: M.Sc. Biotechnology

Semester III

Code of the Course/Subject	Title of the Course/Subject	Total Number of Period
3TB-AEC-III	**Critical Analysis of Classical Papers**	**30 hrs**

The objectives of this course are to familiarize students with classic literature to make them appreciate how groundbreaking discoveries were made without, necessarily, use of high-end technologies.

Students should be able to train in the exercise of hypothesis building and methods of addressing the hypothesis with readily available technology.

How does the Course Module work? Students may be divided in groups and each group may be responsible for one classical paper. Each week there may be a 1.5 hour presentation cum discussion for each of the papers. At the end of the semester each student will be asked to write a mini-review (2-3 pages long) on any one classical paper, other than the one he/she presented/discussed. A list of sixteen classic papers and some suggested reference materials:

Molecular Biology

1. Studies on the chemical nature of the substance inducing transformation of Pneumococcal types: Induction of transformation by a desoxyribonucleic acid fraction isolated from Pneumococcus type III. Avery OT, Macleod CM, McCarty M.; J Exp Med. 1944 Feb 1;79(2):137-58. Note: This paper demonstrates that DNA is the transforming Principle originally described by Fredrick Griffith.

2. Independent functions of viral protein and nucleic acid in growth of bacteriophage Hershey AD and Chase M.; J Gen Physiol. 1952 May;36(1):39-56. Note: Note: This paper demonstrates that DNA, and not protein, component of phages enter bacterial cells.

3. Molecular structure of nucleic acids; a structure for deoxyribose nucleic acid Watson JD and Crick FH; Nature. 1953 Apr 25;171(4356):737-8 Note: In this one page paper Watson and Crick first described the structure of DNA double helix Study help - Watson_Crick_Nature_1953_annotated

4. Transposable mating type genes in Saccharomyces cerevisiae James Hicks, Jeffrey N. Strathern & Amar J.S. Klar; Nature 282, 478-483,1979 Note: This paper provided evidence for ‘cassette hypothesis’ of yeast mating type switches i.e. interconversion of mating types in yeast (S. cerevisiae) occurs by DNA rearrangement.

5. Messelson & Stahl experiment demonstrating semi-conservative replication of DNA. Meselson M and Stahl FW.; Proc Natl Acad Sci U S A. 1958 Jul 15;44(7):671-82 Note: The experiment demonstrating semi-conservative mode of DNA replication is referred to as "the most beautiful experiment in biology"

6. In vivo alteration of telomere sequences and senescence caused by mutated Tetrahymena telomerase RNAs Guo-Liang Yu, John D. Bradley, Laura D. Attardi & Elizabeth H. Blackburn; Nature 344, 126-132, 1990 Note: This paper demonstrates that the telomerase contains the template for telomere synthesis

Cell Biology

1. A protein-conducting channel in the endoplasmic reticulum Simon SM AND Blobel G.; Cell. 1991 May 3;65(3):371-80 Note: This paper demonstrates the existence of a protein conducting channel Study help - A brief history of Signal Hypothesis.

2. Identification of 23 complementation groups required for post-translational events in the yeast secretory pathway Novick P, Field C, Schekman R.; Cell. 1980 Aug;21(1):205-15 Note: In this groundbreaking paper Randy Schekman's group used a mutagenesis screen for fast sedimenting yeast mutants to identify genes involved in cell secretion

3. A yeast mutant defective at an early stage in import of secretory protein precursors into the endoplasmic reticulum Deshaies RJ and Schekman R.; J Cell Biol. 1987 Aug;105(2):633-45 Note: Using another yeast mutation screen Schekman lab identifies Sec61, a component of ER protein Conducting Channel (PCC) Suggested reference paper - A biochemical assay for identification of PCC.

4. Reconstitution of the Transport of Protein between Successive Compartments of the Golgi Balch WE, Dunphy WG, Braell WA, Rothman JE.; Cell. 1984 Dec;39(2 Pt 1):405-16 Note: This paper describes setting up of an in vitro reconstituted system for transport between golgi stacks which eventually paved the way for identification of most of the molecular players involved in these steps including NSF, SNAP etc.

5. A complete immunoglobulin gene is created by somatic recombination Brack C, Hirama M, Lenhard-Schuller R, Tonegawa S.; Cell. 1978 Sep;15(1):1-14 Note: This study demonstrates DNA level molecular details of somatic rearrangement of immunoglobulin gene sequences leading to the generation of functionally competent antibody generating gene following recombination.

6. A novel multigene family may encode odorant receptors: a molecular basis for odor recognition Buck L and Axel R; Cell. 1991 Apr 5;65(1):175-87 Note: This paper suggests that different chemical odorants associate with

different cell-specific expression of a transmembrane receptor in Drosophila olfactory epithelium where a large family of odorat receptors is expressed.

7. Kinesin walks hand-over-hand Yildiz A, Tomishige M, Vale RD, Selvin PR.; Science. 2004 Jan 30;303(5658):676-8 Note: This paper shows that kinesin motor works as a two-headed dimeric motor walking hand-over-hand rather than like an inchworm on microtubule tract using the energy of ATP hydrolysis.

Developmental Biology/Genetics

1. Mutations affecting segment number and polarity in Drosophila Christiane Nusslein-Volhard and Eric Weischaus; Nature 287, 795-801, 1980 Note: This single mutagenesis screen identified majority of the developmentally important genes not only in flies but in other metazoans as well.

2. Information for the dorsal--ventral pattern of the Drosophila embryo is stored as maternal mRNA Anderson KV and Nüsslein-Volhard C; Nature. 1984 Sep 20-26;311(5983):223-7 Note: This landmark paper demonstrated that early dorsal-ventral pattern information is stored as maternal mRNA in flies and devised the method of identifying genes encoding such genes

3. Hedgehog signalling in the mouse requires intraflagellar transport proteins Huangfu D, Liu A, Rakeman AS, Murcia NS, Niswander L, Anderson KV.; Nature. 2003 Nov 6;426(6962):83-7 Note: One of the architects of original fly mutagenesis screens conducted a mouse mutagenes screen which identified a gene Kif3a as a major component of hedgehog signaling pathway. Eventually this discovery revolutionizes our understanding of mechanisms of action of signaling pathways by demonstrating central role of cillia in it. Suggested Reference paper - Design and execution of a embryonic lethal mutation screen in mouse.

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Syllabus Prescribed for M.Sc. II Year PG Programme

Programme: M.Sc. Biotechnology

Semester III

Code of the Course/Subject	Title of the Course/Subject	Total Number of Period
3TB-SEM	**Seminar**	**30 hrs**

Syllabus Prescribed for Two Year PG Programme

Programme: M.Sc. Biotechnology

Semester III

Code of the Course/Subject	Title of the Course/Subject (Laboratory/Practical/Hans-on)	(No. of Periods/Week)
3BTB-LC-VIII	**Bioprocess Engineering & Technology & Down Stream Processing**	**6H/Week**

1. Basic Microbiology techniques

a) Scale up from frozen vial to agar plate to shake flask culture.

b) Instrumentation: Microplate reader, spectrophotometer, microscopy.

c) Isolation of microorganisms from soil samples.

2. Experimental set-up

a) Assembly of bioreactor and sterilization.

b) Growth kinetics.

c) Substrate and product inhibitions.

d) Measurement of residual substrates.

3. Data Analysis

a) Introduction to Metabolic Flux Analysis (MFA).

4. Fermentation

a) Batch.

b) Fed-batch.

c) Continuous.

5. Unit operations

a) Microfiltrations: Separation of cells from broth.

b) Bioseparations: Various chromatographic techniques and extractions.

6. Bioanalytics

a) Analytical techniques like HPLC, FPLC, GC, GC-MS etc. for measurement of amounts of products/substrates

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Programme: M.Sc. Biotechnology

Semester III

Code of the Course/Subject	**Title of the Course/Subject** (Laboratory/Practical/Hans-on)	**(No. of Periods/Week)**

Semester III

Code of the Course/Subject	**Title of the Course/Subject** (Laboratory/Practical/Hans-on)	**(No. of Periods/Week)**
3BTB-LC-IX	**Environmental Biotechnology**	**6H/Week**

Cos

This course aims to introduce fundamentals of Environmental Biotechnology. The course will introduce

major groups of microorganisms- tools in biotechnology and their most important environmental applications.

The environmental applications of biotechnology will be presented in detail and will be supported by examples from the national and international literature.

On completion of course, students will be able to understand use of basic microbiological, molecular and analytical methods, which are extensively used in environmental biotechnology.

1. Detection of coliforms for determination of the purity of potable water.
2. Determination of total dissolved solids of water
3. Determination of dissolved oxygen concentration of water sample
4. Determination of biological oxygen demand (BOD) of sewage sample
5. Determination of chemical oxygen demand (COD) of sewage sample
6. Determine the efficiency of removal of air pollutant using fibrous air filter.
7. Isolation of xenobiont degrading bacteria by selective enrichment technique
8. Test for the degradation of a aromatic hydrocarbons by bacteria
9. Survey of degradative plasmids in microbes growing in polluted environment
10. Effect of Sulphur dioxide on crop plants
11. Estimation of heavy metals in water/soil by Atomic absorption spectrophotometry
12. Estimation of nitrate in drinking water.
13. Role of microorganisms in elevation of heavy metal induced stress I plants

Recommended Textbooks and References:

1. G. M. Evans and J. C. Furlong (2003), Environmental Biotechnology: Theory and Applications, Wiley Publishers.

2. B. Ritmann and P. L. McCarty, (2000), Environmental Biotechnology: Principle & Applications, 2 nd Ed., McGraw Hill Science.

3. Scragg A., (2005) Environmental Biotechnology. Pearson Education Limited.

4. J. S. Devinny, M. A. Deshusses and T. S. Webster, (1998), Biofiltration for Air Pollution Control, CRC Press.

5. H. J. Rehm and G. Reed, (2001), Biotechnology – A Multi-volume Comprehensive Treatise, Vol. 11, 2 nd Ed., VCH Publishers Inc.

6. H. S. Peavy, D. R. Rowe and G. Tchobanoglous, (2013), Environmental Engineering, McGraw-Hill Inc.

Syllabus Prescribed for Two Year PG Programme

Programme: M.Sc. Biotechnology

Semester III

Code of the Course/Subject	**Title of the Course/Subject** (Laboratory/Practical/Hans-on)	**(No. of Periods/Week)**
3BTB-LC-X	**Bioinformatics and Emerging Technologies**	**6H/Week**

The aim of this course is to provide practical training in bioinformatic methods including accessing major public sequence databases, use of different computational tools to find sequences, analysis of protein and nucleic acid sequences by various software packages.

On completion of this course, students should be able to:
• Describe contents and properties of most important bioinformatics databases;
• Perform text- and sequence-based searches and analyze and discuss results in light of molecular biological knowledge;
• Explain major steps in pairwise and multiple sequence alignment, explain principle and execute pairwise sequence alignment by dynamic programming;
• Predict secondary and tertiary structures of protein sequences.

1. Using NCBI and Uniprot web resources.

2. Introduction and use of various genome databases.

3. Sequence information resource: Using NCBI, EMBL, Genbank, Entrez, Swissprot/

TrEMBL, UniProt.

4. Similarity searches using tools like BLAST and interpretation of results.

5. Multiple sequence alignment using ClustalW.

6. Phylogenetic analysis of protein and nucleotide sequences.

7. Use of gene prediction methods (GRAIL, Genscan, Glimmer).

8. Using RNA structure prediction tools.

9. Use of various primer designing and restriction site prediction tools.

10. Use of different protein structure prediction databases (PDB, SCOP, CATH).

11. Construction and study of protein structures using Deepview/PyMol.

12. Homology modelling of proteins.

13. Use of tools for mutation and analysis of the energy minimization of protein structures.

14. Use of miRNA prediction, designing and target prediction tools.

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Syllabus Prescribed for M.Sc. II Year PG Programme

Programme: M.Sc. Biotechnology

Semester III

Code of the Course/Subject	Title of the Course/Subject	Total Number of Period
3TB-P	**Project (Planning, Review, Presentation)**	**30 hrs**

The purpose of this course is to help students organize ideas, material and objectives for their dissertation and to begin development of communication skills and to prepare the students to present their topic of research and explain its importance to their fellow classmates and teachers.

Students should be able to demonstrate the following abilities:
• Formulate a scientific question.
• Present scientific approach to solve the problem.
• Interpret, discuss and communicate scientific results in written form.
• Gain experience in writing a scientific proposal.
• Learn how to present and explain their research findings to the audience effectively.

	Content
Project Proposal Preparation	Selection of research lab and research topic: Students should first select a lab wherein they would like to pursue their project. The supervisor or senior researchers should be able to help the students to read papers in the areas of interest of the lab and help them select a topic for their project. The topic of the research should be hypothesis driven. Review of literature: Students should engage in systematic and critical review of appropriate and relevant information sources and appropriately apply qualitative and/or quantitative evaluation processes to original data; keeping in mind ethical standards of conduct in the collection and evaluation of data and other resources. Writing Research Proposal: With the help of the senior researchers, students should be able to discuss the research questions, goals, approach, methodology, data collection, *etc.* Students should be able to construct a logical outline for the project including analysis steps and expected outcomes and prepare a complete proposal in scientific proposal format for project.
Poster Presentation	Students will have to present the topic of their project proposal after few months of their selection of the topic. They should be able to explain the novelty and importance of their research topic.
Oral Presentation	At the end of their semester, presentation will have to be given by the students to explain work done by them in detail. Along with summarizing their findings they should also be able to discuss the future expected outcome of their work.

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Syllabus Prescribed for M.Sc. II Year PG Programme

Programme: M.Sc. Biotechnology

Semester IV

Code of the Course/Subject	**Title of the Course/Subject**	**Total Number of Period**
4BTB-DSC-XV	**Animal Cell Science and Technology**	**45 hrs**

COs

The objectives of this course is to educate students about the fundamental concepts of animal cell system, bioprocess technology using eukaryotic system and their related applications, thus preparing them to meet the challenges of the new and emerging areas of biotechnology industry.

Students should be able to gain strong understanding on animal based cell cultures system. This will help them to take up animal based biological research as well as placement in the relevant biotech industry. They will be able to analyse the bioprocess from an economics/market point of view.

Unit	**Content**
Unit I	Cell culture laboratory design and equipments - Planning, construction and services; Layout; Sterile handling area; Incubation; Hot room; Air circulation; Service bench; Laminar flow; Sterilizer; Incubator; CO_2 incubator; Refrigerators and freezers; Centrifuge; Inverted stage microscope; Magnetic stirrer; Liquid nitrogen freezers; Slow cooling system for cell freezing; Water bath; Autoclaves and hot air oven; Pipette washers; Water purification system; Fluid handling systems and other equipments; Washing, packing and sterilization of different materials used in animal cell culture; Aseptic concepts; Maintenance of sterility; Cell culture vessels.
Unit II	Media and reagents - Types of cell culture media; Ingredients of media; Physiochemical properties; CO_2 and bicarbonates; Buffers; Oxygen; Osmolarity; Temperature; Surface tension and foaming; Balance salt solutions; Antibiotics, growth supplements; Foetal bovine serum; Serum free media; Trypsin solution; Selection of medium and serum; Conditioned media; Other cell culture reagents; Preparation and sterilization of cell culture media, serum and other reagents.
Unit III	Different types of cell cultures - History of animal cell culture; Different tissue culture techniques; Types of primary culture; Chicken embryo fibroblast culture; Chicken liver and kidney culture; Secondary culture; Trypsinization; Cell separation; Continuous cell lines; Suspension culture; Organ culture; Behaviour of cells in culture conditions: division, growth pattern, metabolism of estimation of cell number; Development of cell lines; Characterization and maintenance of cell lines, stem cells; Cryopreservation; Common cell culture contaminants.
Unit IV	Applications - Cell cloning and selection; Transfection and transformation of cells; Commercial scale production of animal cells, stem cells and their application; Application of animal cell culture for in vitro testing of drugs; Testing of toxicity of environmental pollutants in cell culture; Application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.
Unit V	Scale-up - Cell culture reactors; Scale-up in suspension; Scale and complexity; Mixing and aeration; Rotating chambers; Perfused suspension cultures; Fluidized bed reactors for suspension culture; Scale-up in monolayers; Multisurface propagators; Multiarray disks, spirals and tubes; Roller culture;

	Microcarriers; Disposable bioreactors Perfused monolayer cultures; Membrane perfusion; Hollow fibre perfusion; Matrix perfusion; Microencapsulation; Growth monitoring.

Recommended Textbooks and References:

1. Freshney, (2005), Culture of Animal Cells, 5th Edition, Wiley-Liss.

2. Ed. John R.W. Masters, (2000), Animal Cell Culture - Practical Approach, 3rd Edition, Oxford University Press.

3. Ed. Martin Clynes, (1998), Animal Cell Culture Techniques. Springer

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Syllabus Prescribed for M.Sc. II Year PG Programme

Programme: M.Sc. Biotechnology

Semester IV

Code of the Course/Subject	Title of the Course/Subject	Total Number of Period
4BTB-DSC-XVI	**Vaccine**	**15 hrs**

Unit	Content
Unit I	**Vaccine types & design** History of vaccines, Conventional vaccines; Bacterial vaccines; Viral Vaccines; Vaccines based on routes of administration: parenteral, oral, mucosal; Live attenuated and inactivated vaccine; Subunit Vaccines and Toxoids; Peptide Vaccine.
Unit II	**Immune response to vaccination** Vaccination and immune response; Adjuvants in Vaccination; Modulation of immune responses: Induction of Th1 and Th2 responses by using appropriate adjuvants and antigen delivery systems - Microbial adjuvants, Liposomal and Microparticles as delivery systems; Chemokines and cytokines; Role of soluble mediators in vaccination; Oral immunization and Mucosal Immunity.
Unit III	**Vaccine Technologies** New Vaccine Technologies; Rationally designed Vaccines; DNA Vaccination; Mucosal vaccination; New approaches for vaccine delivery; Engineering virus vectors for vaccination; Vaccines for targeted delivery (Vaccine Delivery systems); Disease specific vaccine design: Tuberculosis Vaccine; Malaria Vaccine; HIV/AIDS vaccine; New emerging diseases and vaccine needs (Ebola, Zika).

Recommended Textbooks and References:

1. Janeway, C. A., Travers, P., Walport, M., & Shlomchik, M. J. (2005). Immuno Biology: the Immune System in Health and Disease. USA: Garland Science Pub.
2. Kindt, T. J., Osborne, B. A., Goldsby, R. A., & Kuby, J. (2013). Kuby Immunology. New York: W.H. Freeman.
3. Kaufmann, S. H. (2004). Novel Vaccination Strategies. Weinheim: Wiley-VCH.
4. Journal Articles (relevant issues) from: Annual Review of Immunology, Annual Review of Microbiology, Current Opinion in Immunology, Nature Immunology, Expert review of vaccines.

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Syllabus Prescribed for M.Sc. II Year PG Programme

Programme: M.Sc. Biotechnology

Semester IV

Code of the Course/Subject	Title of the Course/Subject	Total Number of Period
4BTB-DSC-XVII	**Industrial Biotechnology**	**45 hrs**

Unit I :	**Fermentation products:** Dairy products: Milk processing - Cheese - principles of cheese making. Cheddar Cheese, Swiss Cheese, Surface ripened Cheeses; Mold ripened Cheeses. Cottage and Indian Channa cheese. General principles of manufacture of Yogurt, acidophilus milk, Kefir, Koumiss Fermented foods: Soy sauce, Miso, Sufu, Natto, Idli, fermented fish products, Sauer Krant, pickles, fermentation of Olives, fermented sausages; Production of distilled beverage alcohol, wine, brandy and beer.
Unit II :	**Biopesticide and biofertilizers** **Biopesticides :** Biological control, plant biopesticides or botanical pest control (BPC), Recent interest in Bt biopesticides, Nuclear polyhydrosis virus (NPV), Baculoviruses, Trichoderma and Trichogramma as biopesticides, Genetically engineered bacteria as biopesticide, Impact of biopesticides in sustainable agriculture. **Biofertilizers :** Principles and objectives of Biofertilizers and Integrated Nutrient Management (INM), Need forintegrated nutrient management, Components of integrated nutrient management: Chemical fertilizers, organic fertilizers, legumes as a green manures, vermicompost for sugarcane, organic Farming and organic Food.
Unit III :	**Bioprospecting:** Introduction: Biodiversity prospecting; Biochemical resources from plants and fungi, natural products: the role of natural products in drug discovery, natural products as modern drugs; Prospecting for New Compounds from Plants particularly from Melghat forest: Discovery of novel compounds, Screening of traditional knowledge-based herbal drugs, Preparation of crude compounds, Isolation of pure compounds, bio-assay guided isolation, high throughput screening of extracts. **Bioprospecting from microbes** (Actinomycetes, Bacteria, fungi) with special reference to marine actinomycetes, endophytes and metagenomics by products. Anticancer, antiviral, antibacterial, antifungal, antidiabetics from microbial origin.
Unit IV :	**Industrially important products** Industrial production of alcohol, Acetone, Citric acid, Gluconic acid, Acetic acid, lactic acid; Production of polysaccharides, Penicillin, Xanthan; Industrial enzymes (proteases, pectinases, cellulases and lipases)
Unit V :	**Bionanotechnology and industrial applications** Introduction to bionanotechnology and overview of nanoscale materials; effect of length scale on properties; challenges and opportunities associated with biology on the Nanoscale; top-down and bottom-up approach, methods of nanoparticle synthesis, its characterization and analysis of nanoparticles by different techniques such as UV-Visible spectroscopy, NMR, SEM, TEM, X-RD, FTIR. Synthesis of Nanoparticles by Biological system, Extracellular biosynthesis with a case study of silver and gold nanoparticles, Intracellular biosynthesis case by bacteria.

	Applications of bionanotechnology in various fields.

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Syllabus Prescribed for TWO Year PG Programme

Programme: M.Sc. Biotechnology

Semester IV

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
4BTB-DSE-A	**Cancer Biology**	**30**

COs
Students after completion of this course will be able to…..

1. analyse the changes in the cells leading to cancer
2. formulate new assay systems for detection of cancer.
3. Get motivated to design markers.
4. help to develop new drugs

Unit	Content
Unit I	**Hallmarks of cancer--** Introduction to cancer, the nature of cancer cancer types and their prevalence, class organization. Hall Marks of Cancer: Evasion of Apoptosis, Limitless replicative potential, Sustained Angiogenesis, Inflammation. Diseased and cancerous cell: morphological and microscopic features, important tumour markers.
Unit II	**Molecular basis of Key Players -**Carcinogens, tumour virology, oncogenes, tutor suppressor genes, cell cycle regulation in cancer development, role of genomic instability in cancer pathogenesis, Histone acetylases/deacetylases in cancer progression, Understanding of post transcriptional and post translational modifications in cancer cell, angiogenesis and malignancy, stem cell biology & cancer stem cells.
Unit III	**Altered pathways -**Hypoxia/ tumour cell microenvironment and important signalling pathways involved in cancer progression, Pathways involved in cell differentiation/ immortalization in cancer. Systems Biology in cancer, epigenetics in cancer, MicroRNAs and cancer, cell death: necrosis and apoptosis.
Unit IV	**Techniques involved in detection -** Use of Immunoglobins, Biomarkers in detection, cytological screenings, karyotyping, chromosome painting, FISH, other techniques involved in detection. Role of Histopathological & Immunocytochemical techniques in cancer diagnostics and research, initiation and propagation of cancer cells in cell culture systems: Evaluation of important properties and their relevance with human biology.
Unit V	**Conventional and new treatments-**Discovery and clinical validation of a targets in cancer, tools, techniques & important parameters involved in screening new bioactive(s) as possible anticancer agent(s), Cell cycle regulators: Role as therapeutic targets in cancer, gene silencing and RNAi technology in cancer treatment.

Course Material/Learning Resources

1. The Biology of Cancer. Weinberg R. A. (2013), 2nd Ed. Garland Publishing Inc, ISBN-10 : 0815342209, 978-0815342205
2. Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics. Pecorino Lauren, (2021), 5th Ed. OUP Oxford, ISBN-10 : 0198833024, 978-0198833024
3. The Cell: A Molecular Approach. Cooper G. M and Housman R. E, (2009), 5th Ed. Sinauer Associates Inc, ISBN-10 : 0878933972, 978-0878933976
4. https://www.nature.com/scitable/ebooks/cntNm-16550193/
5. https://bookboon.com/en/introduction-to-cancer-biology-ebook
6. https://themedicalbiochemistrypage.org/category/specialized-topics/cancer/

Part B

Syllabus Prescribed for TWO Year UG/PG Programme

Programme: M.Sc. Biotechnology Semester IV

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
4BTB-DSE-B	**Molecular Basis of Drug Discovery**	**30**

COs

Students after completion of this course will be able to…..

1. Recall the major steps of drug development and their corresponding processes
2. Interpret relationships between molecule concentration and enzyme or receptor activity
3. Compute a molecule's pharmacokinetic parameters from *C*p-time data points
4. Correlate a molecule's structure to its metabolic behaviour.
5. Prioritize the viability of weakly active molecules for potential drug development
6. Propose molecules with improved properties based upon data from related structures

Unit	Content
Unit I	**Pre-Regulatory Medicine:** Natural products, Early Synthetic drugs, Pharmacophores, Need for Regulations. Drug development outline, Target based drug discovery and Phenotype based discovery, drug repurposing. Concept to market
Unit II	Proteins and their structures, Enzymes: Enzyme kinetics, Enzyme inhibition and its measurements, IC50 and Ki, Receptors and Ligands, Occupancy theory: Emax and Kd, Binding and Response, Upregulation and down-regulation.
Unit III	**Blood and drug transport**: Serum binding, ADME, Pharmacokinetics, Oral Bioavailability, Understanding Cp and complexity of dosing, Metabolism of drug, Pro-drug.
Unit IV	**Binding, Structure and Diversity:** Intermolecular forces, Drug Target Complementarity, Molecular diversity, Molecular libraries, Building libraries.
Unit V	**Lead Discovery:** In vitro screening, fragment based screening, Filtering hits, Selective optimization of side activities, Natural products Lead optimization: functional group replacements, Alkyl group replacements, Isosters, Directed Combinatorial Libraries, Peptidomimetics

Course Material/Learning Resources

1. MEDICINAL CHEMISTRY: THE MOLECULAR BASIS OF DRUG DISCOVERY: Medicinal Chemistry Made easy. Barnabas Ifitumi Samuel .ISBN-13: 979-8458903875
2. Basic Principles of Drug Discovery and Development. (11th Edition). Benjamin Blass. ISBN: 9780124115255
3. Drug Discovery and Evaluation Pharmacological Assays (2nd Edition). H. Gerhard Vogel (Ed.). ISBN 3-540-42396-6 Springer-Verlag
4. Computer-Aided Drug Design Virtual Lab https://vlab.amrita.edu/index.php?sub=3&brch=277

Part B

Syllabus Prescribed for TWO Year PG Programme

Programme: M.Sc. Biotechnology Semester IV

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
4BTB-DSE-C	**Clinical Trial and Research**	**30**

COs

Students after completion of this course will be able to…..

1. Demonstrate competency in biopharmaceutical clinical trial research designs and regulatory affairs management to meet the health and medical needs of current and future biopharmaceutical product consumers
2. Evaluate critical domestic and global regulatory and health care issues that challenge and influence biopharmaceutical product development
3. Effectively assess and manage ethical clinical trial programs and biopharmaceutical development projects
4. Manage innovative biopharmaceutical/biotechnology products through the discovery processes and into the clinical trial phases via identifying research questions and testable hypotheses
5. Demonstrate advanced critical thinking skills necessary to enhance employment opportunities or advance within the biopharmaceutical industry
6. Effectively communicate and collaborate with health care providers and regulatory agencies to develop culturally diverse domestic and global strategies for biopharmaceutical product approvals

Unit	Content
Unit I	**Clinical trial Introduction:** Fundamentals of clinical research, Introduction to healthcare, Introduction to Good Clinical practices, Communication skill, Introduction to New Drug Development process, Preclinical studies: Selection of animals, selection of doses, protocol preparation and execution. Different phases of clinical trials: Phase I, Phase II, Phase III, Bridging studies, Post marketing studies, Sample size determination and Power of a study, Blinding and unblinding of subjects.
Unit II	**Regulatory Guidelines and Quality assurance** Clinical Research regulations in India – CDSCO / ICMR guidelines, Schedule Y, Clinical trial application requirements in India, Investigational New Drug (IND), An abbreviated new drug application (ANDA and New Drug application (NDA). Guidelines from, International Council for Harmonisation (ICH), United states-Food and Drugs administration (US-FDA), Medicines and Healthcare Products Regulatory Agency (MHRA) and Clinical Research regulations in Europe (EMEA). Quality Assurance and Quality Control in Clinical Trials, Audit conducts and compliances, Preparing for FDA/ Pharmacovigilance inspections, Fraud and misconduct management.
Unit III	**Clinical Trial Ethics and safety:**

	Ethics committees, constitution and practices, Declaration of Helsinki and Informed consent process, Liability and indemnity in clinical trials (Insurance and Indemnity: roles and responsibility), Ethics and clinical trials in special population. Adverse events and reporting of adverse events, Risk –benefit assessment of adverse events. Ethical committees (EC), Data Safety Monitoring Board (DSMB).
Unit IV	**Scientific Writing and data management-** Clinical Protocols, Investigator's Brochure, Informed Consent Form, Case report forms (CRF), Contracts and agreements, Trial Master File preparation and maintenance, Investigator Site File, Pharmacy File, Dairy Cards Clinical Data Management (CDM):, Data management plan, Study set-up, Data entry, CRF tracking and corrections, Central lab, Interactive Web Response Systems (IWRS) Interactive Voice Response Systems (IVRS), source data. Data cleaning, managing laboratory data, Data transfer and database lock, Quality Control and Quality Assurance in CDM, Data mining and warehousing Clinical Data Analysis.
Unit V	**Clinical Trial Management-** Clinical site management: Review of source documents, CRF, Inform consent form (ICF), investigational Product (IP) storage, accountability and reconciliation, Study Procedure, EC communications, Safety reporting, Monitoring visit reporting and follow-up Close-Out visit: Study related documents collection, Archival requirement, Investigational Product reconciliation and destruction, Close-Out visit report. Investigational Drug Management: Storage and transport of drugs, packaging and labelling of materials for blinded and unblinded studies. Query management.

Course Material/Learning Resources

1. Lawrence M. Friedman, Curt D. Furberg, David DeMets. Fundamentals of Clinical Trials. Springer Cham.
2. Warren S. Browner. Publishing and Presenting Clinical Research, Third Edition. Lippincott Williams & Wilkins (LWW)
3. Dr. Stephen B Hulley, Steven R Cummings, Warren S Browner. Designing Clinical Research. Lippincott Williams & Wilkins (LWW)
4. Susanne Prokscha. Practical Guide to Clinical Data Management, Third Edition. CRC Press
5. WHO. Handbook for Good Clinical Research Practice: guidance for implementation. https://apps.who.int/iris/handle/10665/43392

Part B

Syllabus Prescribed for TWO Year PG Programme

Programme: M.Sc. Biotechnology Semester IV

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
4BTB-DSE-D	**Phyto-secondary Metabolites and its Bioactivity**	**30**

Course Outcomes

Students should be able to:

1. Identify and characterize the plants which produces various metabolites.
2. Identify major categories of plant metabolites and their classification, identification and analysis.
3. Identify and demonstrate various lab techniques for their isolation and purification.
4. Demonstrate and evaluate interactions between metabolites for preventing human heal**th.**

.**Unit**	**Content**
Unit I	Strategies For Discovery Of Bioactive Phytochemicals, Strategies For Choosing A Plant Species Or Plant Tissue, Tools For Determination Of Active Components From Plants, Isolation And Characterization Of Plant Constituents, Phytochemical Analysis And Assay.
Unit II	QSAR And Molecular Modelling of Bioactive Phytochemicals 1. Lignans And Tannis, As Antiviral And Antitumour Agents 2. Isoflavonoids As Phytoestrogens And Flavonoids As Antiestrogens 3. Antioxidants Phenolics: Physiochemical Properties 4. Curcumins And Related Compounds As Blockers Of Signal Transduction In Inhibition Of Tumour Promotion 5. Bioactive Components For Treatment Of Diseases.
Unit III	Phyto-Antimicrobial (PAM)- Agents As Multifunctional Food Additives; PAM From Oils; PAM From Spices; PAM From Herbs (Alove); PAM Thiosulphonates From Garlic; PAM Polyphenolics From Green Tea.
Unit IV	Phytobioactives From Plants, Their Compositions And Original Constituents, Natural Extracts; Specific Process Development Require High Performing Technology Such As Extraction With Supercritic CO2; Enzymatic Biopurification Or Bioconversion; Characterizing Fraction And Components By Analytical Methods Including HPLC, TLC, Flurometry And Spectrophotometry.
Unit V	Validating Structure And Functional Claims Using An Assay Of Invitro Cell Based And Cell Free Assays Targeted Towards- Cosmatics And Neutraceutical Applications; Some Of Assays Including Antioxidant Activity; Antimicrobial Activity: UV Protection; Antiinflamatery Effects; Skin Cell Regeneration; Antimutagenic Activity; Induction Of Chemopreventive Enzymes.

Course Material/Learning Resources

1. Anita Patil (2020). Phytosecondary metabolites: isolation, characterization and their biological properties. STUDERA PRESS ISBN 978-93-85883-19-4
2. Crozier Alan Et.Al (2013). Plant Secondary Metabolites Occurrence Structure and Role In The Human Diet by Crozier Alan Et.Al, Wiley India Pvt Ltd
3. Mohammed Wasim Siddiqui, Kamlesh Prasad (2016). Plant Secondary Metabolites, Biological and Therapeutic Significance. Volume 1. CRC Press
4. Mohammed Wasim Siddiqui, Vasudha Bansal, Kamlesh Prasad (2016). Plant Secondary Metabolites, Stimulation, Extraction, and Utilization. Volume 2. CRC Press
5. Satish C Bhatla, Manju A. Lal (2019). Plant Physiology, Development and Metabolism. Springer
6. Swapna Thacheril Sukumaran, Shiburaj Sugathan, Sabu Abdulhameed (2020).Plant Metabolites: Methods, Applications and Prospects. Springer

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Syllabus Prescribed for Two Year PG Programme

Programme: M.Sc. Biotechnology Semester IV

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
4BTB-DSE-E	**Nanobiotechnology**	30

COs

On successful completion of this course, students should be able to -

1. Develop a basic scientific concept behind the properties of materials at nano-meter scale,
2. Design applications of Nanotechnology inspired from Nature.
3. Formulate methods of Nanomaterial synthesis.
4. Derive information about nanomaterial using different characterization techniques

Unit	Content
Unit I	**Introduction to Bio-nanotechnology:** Concepts, historical perspective and overview of nanoscale materials; effect of length scale on properties; challenges and opportunities associated with biology on the Nanoscale, Nanotechnology in Nature (Lotus effect, Gecko Effect and Iridescence Phenomena); Biomimetic etc.
Unit II	**Nanomaterial Synthesis:** Top-down and bottom-up approach of nanomaterial Synthesis, Different methods of nanomaterial synthesis (Physical, Chemical, Biological and Hybrid), Synthesis of Nanoparticles by Biological system, Extracellular biosynthesis with a case study of silver and gold nanoparticles, Intracellular biosynthesis case by Bacteria.
Unit III	**Characterization Techniques:** characterization and analysis of nanoparticles by different techniques such as UV-Visible spectroscopy, Nuclear Magnetic Resonance (NMR), Electron Microscopy (SEM, TEM, STEM) , Probe Microscopy (AFM), X-RD, FTIR, ICP-MS etc
Unit IV	**Applications of nanomaterials :** Nanoparticles for diagnostics and imaging concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development, Nanomaterials for catalysis, development and characterization of nano-biocatalysts, application of nano-scaffolds in synthesis, applications of nano-biocatalysis in the production of drugs and drug intermediates.
Unit V	**Nanotoxicity** : Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different stratas of environment; Ecotoxicity models and assays; Life Cycle Assessment, containment; Guidelines and Best Practices for Safe Handling of Nanomaterials in Research Laboratories and Industries.

Course Material/Learning Resources

1. Gero Decher, Joseph B. Schlenoff, (2003); Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials, Wiley-VCH Verlag GmbH & Co. KGaA.
2. David S. Goodsell, (2004); Bionanotechnology: Lessons from Nature; Wiley-Liss
3. Neelina H. Malsch (2005), Biomedical Nanotechnology, CRC Press
4. Greg T. Hermanson, (2013); Bioconjugate Techniques, (3rd Edition); Elsevier
5. Recent review papers in the area of Nanomedicine.

Weblink to Equivalent MOOC on SWAYAM if relevant:
https://onlinecourses.nptel.ac.in/noc19_bt28/preview
https://nptel.ac.in/courses/118107015
https://nptel.ac.in/courses/118102003
https://onlinecourses.nptel.ac.in/noc19_mm21/preview

Weblink to Equivalent Virtual Lab if relevant:
https://youtu.be/ebO38bbq0_4
https://youtu.be/Vs5j0CLPHlI

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Syllabus Prescribed for TWO Year UG/PG Programme

Programme: M.Sc. Biotechnology Semester IV

Code of the Course/Subject	Title of the Course/Subject	(Total Number of Periods)
4BTB-DSE-F	**DNA Fingerprinting**	**30**

COs

Students after completion of this course will be able to-

1. learn the basics of DNA Fingerprinting,
2. use technique of DNA Fingerprinting, Linage markers,
3. solve problems of DNA fingerprinting,
4. follow ethics of DNA analysis
5. carryout DNA analysis and legal aspects
6. study the classical papers and case study with an outcome to learn the presentation of case studies.

DNA Fingerprinting, applications and legal aspects

Unit	Content
1.	**RFLP base DNA Fingerprinting** History of DNA profiling, RFLP based DNA profiling, multilocus probes, locus specific probes, applications in Forensic science¸ advantages and disadvantages of RFLP based DNA profiling
2.	**PCR based DNA Fingerprinting** PCR STR based DNA profiling, Automation in detection of PCRSTR profile, classification of STR, history of STR for DNA profiling, STR profiling used for sex determination, problems of Amelogenin markers, advantages and disadvantages of STR based DNA profiling, problems of DNA profiling.
3.	**Linage markers-** mt DNA, method of mt DNA analysis, Y-STR profiling, methodology for Y STR analysis, Y STR database and its application, technique, Applications of lineage markers. Problems of Linage markers.
4	**DNA analysis: Legal system, application of database, ethics and social implication** DNA and Legal system in India, Indian DNA bill, DNA fingerprinting database, Combined DNA Indexing System (CODIS). Forensic genetics and ethical, legal and social implications
5	**Case studies using DNA analysis** At least 4 case studies for DNA analysis using research papers e.g Czar Nicohlas II case, Prince Branciforte Barresi, Anna Anderson case etc

Course Material/Learning Resources

1. Gill et al (1985) Forensic application of DNA Fingerprints. Nature 318, 577.
2. Jefferys et al (1985) Individual specific DNA fingerprints of Human DNA. Nature 316, 76.
3. Jefferys et al (1985) Positive identification of an immigration test case using human DNA fingerprints. Nature 317,818.
4. Jefferys et al (1985) Hypervariable Minisatellite regions in human DNA Nature, 314, 67
5. Rogave et al (2008) Genomic identification in the historical case of the Nicholas II royal family, PNAS www.pnas.org/cgi/content/full/ 0811190106/DCSupplemental
6. Clobel et al (2009) The Identification of the Two Missin g Romanov Children Using DNA Analysis, Plos 4, e4838
7. Wayman and White (1980) A highly polymorphic locus in human DNA, Proc. Nati. Acad. Sci. USA Vol. 77, No. 11, pp. 6754-6758,
8. An Introduction to Forensic Genetic (2007) William Goodwin ed
   John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex PO19 8SQ, England
9. DNA Technology in Forensic Science DNA Technology in Forensic Science
10. Mildred K Cho and Pamela Sankar (2004) Forensic genetics and ethical, legal and social implications beyond the clinic, Nat Genet. 2004 November ; 36(11 Suppl): S8–12.

Part B

Syllabus Prescribed for M.Sc. II Year PG Programme

Programme: M.Sc. Biotechnology

Semester IV

Code of the Course/Subject	**Title of the Course/Subject**	**Total Number of Period**
4BTB-LC-X	**Animal Cell Science & Technology**	30 **hrs**

Cos

The objectives of this course is to educate students about the fundamental concepts of animal cell system, bioprocess technology using eukaryotic system and their related applications, thus preparing them to meet the challenges of the new and emerging areas of biotechnology industry.

Students should be able to gain strong understanding on animal based cell cultures system. This will help them to take up animal based biological research as well as placement in the relevant biotech industry. They will be able to analyse the bioprocess from an economics/market point of view.

1. Aseptic Techniques I: Pipeting and Transfer of fluids
2. Aseptic Techniques II: Preparation of medium for use.
3. Introduction to cell culture
4. Preparation and sterilization of water
5. Preparation and sterilization of Dulbecco's Phosphate Buffer Saline (D-PBS) without Ca++ and Mg++.
6. Preparation of Stock medium from powder and sterilization by filtration.
7. Preparation of pH standards for comparison of cell culture media.
8. Counting cells by Haemocytometer and Electronic counter
9. Primary culture technique for chicken embryo fibroblast.
10. Secondary culture of chicken embryo fibroblast.
11. Cultivation of continuous cell lines.
12. Quantification of cells by trypan blue exclusion dye.
13. Isolation of lymphocytes and cultivation of lymphocytes.
14. Staining of monolayer cell culture
15. Study of effect of toxic chemicals on cultured mammalian cells
16. Study of effect of virus on mammalian cells.
17. Suspension culture technique
18. Cryopreservation of primary cell cultures and cell lines.

Recommended Textbooks and References:

1. Freshney, (2005), Culture of Animal Cells, 5th Edition, Wiley-Liss.

2. Ed. John R.W. Masters, (2000), Animal Cell Culture - Practical Approach, 3rd Edition, Oxford University Press.

3. Ed. Martin Clynes, (1998), Animal Cell Culture Techniques. Springer

4. ATCC Animal Cell Culture Guide - https://www.atcc.org/resources/culture-guides/animal-cell-culture-guide

5. Animal tissue culture principles and applications - https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7325846/

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Syllabus Prescribed for M.Sc. II Year PG Programme

Programme: M.Sc. Biotechnology

Semester IV

Code of the Course/Subject	Title of the Course/Subject	Total Number of Period
4BTB-LC-XI	**Industrial Biotechnology**	30 **hrs**

CO

CO:The objectives of this course are to provide students with hands on knowledge of the primary unit operations involved in downstream processing involved in food and agriculture industry. Students can get complete knowledge about the agro or food industry, thus they will be capable of design the goal.

1. Lab scale production of alcohol and acetic acid.
2. Production of amylase, pectinase and cellulose using microbial cultures.
3. Preparation, production and formulation of microbial biopesticide (bacteria, fungi, viruses) in lab.
4. Demonstration of modern techniques used in food analysis for quality assurance.
5. Demonstrate the various techniques to assess the microbial contamination in food products.
6. Demonstrate the presence of food adulterine in given samples.
7. .Demonstrate the presence anti-microbial metabolites from medicinal plants.
8. Demonstrate the effect of addition of organic fertilizers, vermin-compost and bio-pesticides on growth of plant in pot culture.
9. Isolation and characterization of mycorrhizal fungi (AMF) from root nodules.
10. To demonstrate the production of nanoparticles from microbial culture.

Recommended Textbooks and References:

1. Reinhold company, New York. Modern Food Micro-Biology by J. M. Jay, (1986), Van Nostrand 2.
2. Pergamon Press. Comprehensive Biotechnology Vol. 1- 4 : M.Y. Young (Eds.)
3. Biotechnology : A Text Book of Industrial Microbiology : T.D. Brock, Smaeur Associates, 1990.
4. Industrial Microbiology : L.E. Casida, Willey Eastern Ltd., 1989.
5. 1987. Industrial Microbiology : Prescott & Dunn, CBS Publishers,
6. Enfors & L Hagstrom (1992), RIT, Stockholm. Bioprocess Technology- fundamentals and applications, S O
7. Ratledge & A Sasson, Cambridge Univ. Press, Cambridge. Biotechnology, Economic & Social Aspects : E.J. Dasilva, C Ratledge & A Sasson, Cambridge Univ. Press, Cambridge
8. Crueger and A. Crueger. Biotechnology - a hand book of industrial microbiology : W.
9. Microbial Biotechnology : A. N. Glazer and H. Nikaids.

Part B

Syllabus Prescribed for M.Sc. II Year PG Programme

Programme: M.Sc. Biotechnology

Semester IV

Code of the Course/Subject	Title of the Course/Subject	Total Number of Period
4BTB-P	**Project- Laboratory Work**	**30 hrs**

Course Objectives

The objectives of this course are to prepare the students to adapt to the research environment and understand how projects are executed in a research laboratory. It will also enable students to learn practical aspects of research and train students in the art of analysis and thesis writing.

Student Learning Outcomes

Students should be able to learn how to select and defend a topic of their research, how to effectively plan, execute, evaluate and discuss their experiments. Students should be able to demonstrate considerable improvement in the following areas:

- In-depth knowledge of the chosen area of research.
- Capability to critically and systematically integrate knowledge to identify issues that must be addressed within framework of specific thesis.
- Competence in research design and planning.
- Capability to create, analyse and critically evaluate different technical solutions.
- Ability to conduct research independently.
- Ability to perform analytical techniques/experimental methods.
- Project management skills.
- Report writing skills.
- Problem solving skills.
- Communication and interpersonal skills.

	Content
Planning & performing experiments	Based on the project proposal submitted in earlier semester, students should be able to plan, and engage in, an independent and sustained critical investigation and evaluate a chosen research topic relevant to biological sciences and society. They should be able to systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions. Senior researchers should be able to train the students such that they can work independently and are able to understand the aim of each experiment performed by them. They should also be able to understand the possible outcomes of each experiment.
Thesis Writing	At the end of their project, thesis has to be written giving all the details such as aim, methodology, results, discussion and future work related to their project. Students may aim to get their research findings published in a peer-reviewed journal. If the research findings have application-oriented outcomes, the students may file patent application.
Oral Presentation	At the end of their semester, presentation will have to be given by the students to explain work done by them in detail. Along with summarizing their findings they should also be able to discuss the future expected outcome of their work.

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Syllabus Prescribed for M.Sc. II Year PG Programme

Programme: M.Sc. Biotechnology

Semester IV

Code of the Course/Subject	**Title of the Course/Subject**	**Total Number of Period**
4BTB-SEC-II	**Introduction to programming using 'Python'**	30 hrs

CO:

Course Objectives

The objectives of this course are to prepare the students to adapt to new developments in the research field. It will enable them for the proper data analysis as well as planning the experiments.

Student Learning Outcomes
Students should be able to analyse their data in a simple and easy form. They should be able to write their own programmes and use for analysis and own experiments.

- Basic knowledge of Python programming
- Debugging their own syntax
- Predicting length of restriction fragments
- Efficiently create, use and modulate FAST files
- Design experiments using knowledge of AT content, intron length etc.

Unit 1	**Introduction of Python**: Need of Python programming for Biology, Simple data types, collection data types, simple operations.
Unit 2	**Basics of Python**: Printing and manipulating text: Finding length of the string, Tools for manipulating strings, concatenation, replacement, extracting part of string, calculating AT content, complementing DNA, finding restriction fragment length, splicing out introns.
Unit 3	**Reading and writing files:** Opening and closing files, dealing with new line, writing text to the file, Writing FASTA files, Writing multiple FASTA files.
Unit 4	**Lists and loops-**Creating lists and retrieving elements, working with list elements, writing a loop, indentation errors, splitting string to make list
Unit 5	**Writing our own function-**Need of writing own function, defining a function, improving a function, testing functions and debugging. Conditional tests, else, elif statements, while loop, writing true or false.

Recommended Textbooks and References:

1. Mitchell Model (2009). Bioinformatics programming using Python. O'Reilly Media, Inc., 1005 Gravenstein Highway North, Sebastopol, CA 95472.

2. T. J. Stevens and Wyne Boucher (2015). Python programming for Biology: Bioinformatics and beyond, Cambridge University Press, University Printing House, Cambridge CB2 8BS, United Kingdom

3. Martin Jones (2013) Python for Biologists. http://pythonforbiologists.com

www.pythonlearn.org