DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY,
CHHATRAPATI SAMBHAJINAGAR.

CIRCULAR NO.SU/M.Sc/College./NEP/95/2024

It is hereby inform to all concerned that, the Revised syllabi prepared by the Board of Studies/ Ad-hoc Boards & recommended by the Dean, Faculty of Science & Technology, **Academic Council at its meeting held on 08 April 2024 has accepted** the following Syllabi under the Faculty of Science & Technology **as per Norms of National Education Policy -2020** run at the Affiliated Colleges, Dr.Babasaheb Ambedkar Marathwada University as appended herewith.

Sr.No.	Courses	Semester
1.	**M.Sc.Zoology**	**IIIrd & IVth semester**
2.	**M.Sc. Biotechnology**	**IIIrd & IVth semester**
3.	**M.Sc.Bioinformatics**	**IIIrd & IVth semester**
4.	**M.A./M.Sc.Mathematics**	**IIIrd & IVth semester**

This is effective from the Academic Year 2024-25 and onwards.

All concerned are requested to note the contents of this circular and bring the notice to the students, teachers and staff for their information and necessary action.

University Campus,
Aurangabad-431 004.
REF.NO.SU/2024/26472-80
Date:- 20.05.2024

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Deputy Registrar,
Academic Section

Copy forwarded with compliments to :-

1] **The Principal of all concerned Colleges,**
Dr. Babasaheb Ambedkar Marathwada University,

2] **The Director, University Network & Information Centre, UNIC, with a request to upload this Circular on University Website.**

Copy to :-

1] **The Director, Board of Examinations & Evaluation,** Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.
2] The Section Officer,[M.Sc.Unit] Examination Branch, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.
3] The Programmer [Computer Unit-1] Examinations, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.
4] The Programmer [Computer Unit-2] Examinations, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.
5] The In-charge,[E-Suvidha Kendra], Rajarshi Shahu Maharaj Pariksha Bhavan, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.
6] The Public Relation Officer, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.
7] The Record Keeper, Dr.Babasaheb Ambedkar Marathwada University, Chhatrapati Sambhajinagar.

DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY, CHHATRAPATI SAMBHAJINAGAR

(NAAC Accredited with 'A' Grade)

FACULTY OF SCIENCE & TECHNOLOGY

2 Years P.G. Programme in Science

(M. Sc.)

Course Structure and Curriculum
(Outcome Based Credit System)

For affiliated colleges and Institutions

As Per National Education Policy 2020

(To be implemented from Academic Year 2024-25)

For

M.Sc. (III and IV semester)
Subject: -Biotechnology

M E Patil

Preamble: Postgraduate Courses in Biotechnology

Welcome to the postgraduate courses in Biotechnology! Our programs are designed with a clear vision to foster holistic development, encourage interdisciplinary learning, and equip students with the skills and knowledge needed to excel in the dynamic field of Biotechnology. By embracing the principles and objectives of the National Education Policy (NEP) 2020, our courses strive to create a transformative and inclusive educational experience that prepares students for a successful, responsible, and adaptable future. At the core of our courses lies a commitment to nurturing well-rounded individuals with a deep understanding of the principles, applications, and ethical dimensions of biotechnology. We embrace the ethos of holistic development, combining rigorous theoretical knowledge with practical skills, and hands-on experiences. Through interactive lectures, laboratory sessions, and real-world case studies, students are encouraged to explore the connections between diverse subject areas, fostering a spirit of interdisciplinary thinking. Our courses emphasize skill development and research, equipping students with cutting-edge techniques and innovative approaches to address global challenges in biotechnology. By engaging in research-based projects and cultivating an entrepreneurial mindset, students are empowered to contribute to advancements in the field and make a positive impact on society. Exclusivity and diversity are fundamental to our courses. We celebrate the richness of ideas and experiences brought by each student, ensuring equal opportunities for all to excel. Our teaching methodologies cater to diverse learning styles, inspiring curiosity, critical thinking, and ethical conduct. The global relevance of our courses is amplified through international perspectives, emerging trends, and best practices in biotechnology. By incorporating digital literacy and sustainability consciousness, we prepare students to navigate the digital age responsibly and contribute to a greener future. As educators, we encourage continuous evaluation and foster a culture of lifelong learning. Our commitment extends beyond the classroom, inspiring students to seek knowledge beyond the curriculum and embrace self-directed learning. With a focus on employability, our courses equip students with the skills to thrive in the competitive job market or embark on entrepreneurial ventures. We aim to nurture professionals who can drive positive change and address societal needs through biotechnological innovations.

The courses emphasize a strong foundation in theoretical principles and the latest advancements in biotechnology. Graduates are well-prepared to contribute to the expanding body of scientific knowledge in the field and drive progress through research and innovation. Biotechnology has the potential to address pressing global challenges, such as food security, healthcare, environmental sustainability, and renewable energy. Through specialized courses and practical experiences, students gain insights into how biotechnological applications can contribute to solving these challenges. Biopharmaceutical courses provide students with expertise in drug development and personalized medicine, allowing them to contribute to the discovery and production of life-saving medications and therapies. Courses on animal and plant biotechnology equip students to develop improved crop varieties, disease-resistant livestock, and sustainable agricultural practices, ultimately contributing to enhanced food production and agricultural sustainability. The courses focus on environmental consciousness, green technologies, and bioenergy production. Graduates are empowered to contribute to sustainable practices and reduce the environmental impact of industrial processes. Regulatory affairs courses provide students with the

knowledge and skills to navigate complex regulations and ethical considerations in the biotechnology industry. Graduates can ensure compliance and ethical practice in biotechnological research and applications. Courses on biopharmaceuticals and genomic technologies prepare students to work on precision medicine approaches, allowing them to contribute to treatments tailored to individual patients' needs. The courses cultivate an entrepreneurial mindset, empowering graduates to create start-ups or lead biotechnology-related ventures, thus contributing to economic growth and job creation. The interdisciplinary nature of the courses encourages collaboration across various fields, leading to more inclusive research and diverse perspectives in solving complex challenges. The courses inspire a culture of lifelong learning, encouraging graduates to stay updated with the latest advancements in biotechnology and continuously improve their skills and knowledge. Overall, the design of these courses prepares students to become well-rounded professionals capable of making meaningful contributions to biotechnology's goals for mankind. Whether through scientific discoveries, novel therapies, sustainable solutions, or ethical practices, graduates can play a crucial role in shaping a better future for humanity through biotechnological advancements.

Some of the key areas of focus of the curriculum include Protein Expression and Engineering, Formulation and Drug Discovery, Pharmacology and Toxicology, Biopharmaceutical Production, Analytical Techniques, Quality Control, International Regulatory Framework, Drug Approval Processes, Biotechnology Regulations, Embryonic Development, Stem Cell Culture, Tissue Engineering, Reproductive Biotechnology, Transgenic Animals, Animal Cloning, Enzyme Assays, Cellular Respiration and Biofuel Production. By incorporating these advanced aspects into the courses, students are exposed to the forefront of biotechnological research and applications. The focus on cutting-edge techniques and emerging trends prepares them to be future leaders in the field and make significant contributions to scientific advancements and industry innovations.

In conclusion, our postgraduate courses in Biotechnology are founded on the principles of the NEP 2020, with a mission to nurture versatile, socially responsible, and globally aware biotechnologists. We are excited to embark on this educational journey together, empowering you to shape the future of biotechnology and make a meaningful difference in the world.

Vision

Dr Babasaheb Ambedkar Marathwada University, Aurangabad plans to bring about radical changes in the curriculum, teaching and evaluation. The vision of the university is to groom the finest breed of citizens equipped with knowledge and talent to serve the society. The university aspires to march forward to achieve benchmarking of our academic practices against world class standards.

Mission

Dr Babasaheb Ambedkar Marathwada University, Aurangabad adopted with the new educational reforms of NEP 2020 is to empower future generations through a holistic and inclusive education. It aims to revolutionize the educational landscape by equipping students with knowledge, skills, and values to thrive in a rapidly changing world. The key pillars of this mission include universal access and equity, promoting lifelong learning and skill development, fostering a multidisciplinary and flexible

curriculum, embracing technology for personalized learning, empowering teachers, promoting inclusivity and diversity, encouraging research and innovation, and integrating sustainable development and environmental consciousness. By uniting stakeholders, NEP 2020 envisions a transformative educational landscape that empowers future generations to contribute positively to society and build a brighter future.

PROGRAMME OUTCOMES (POs)

This programme of master's in Biotechnology focuses on in-depth use of technologies pertaining to microorganisms, plant and animal Science. The syllabus we designed caters the needs of industries, academics and research scope in the field of Biotechnology with special emphasis to eradicate environmental issues and developing skill sets in Molecular Biology, Bioinstrumentation, Entrepreneurship in Biotechnology, Bioinformatics and other advance domains like AI & System Biology, Synthetic Biology and Intellectual property rights along with bioethical issues. In spite of these the programme outcomes is expected as,

- PO1: Impart dissertation work that develop critical thinking, problem solving, inculcating research aptitude and knowledge, teamwork, planning, interpretation and analysis in the domain of Biotechnology.
- PO2 Learn technical skills through laboratory sessions, research projects and develop self-directed experiential learning.
- PO3 Develop a technical skill set for employability, entrepreneurship and a basic research aptitude.
- PO4 Inculcating the wisdom and subtleties of work ethics of an industry and research organization in biotechnology and allied domains.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO1 Consolidation the fundamentals and principles of basic and applied aspects of Biotechnology with an aim to serve the society.

• PSO2 Develop a technical skill set for generating, analyzing and interpreting scientific data for employability, entrepreneurship and research aptitude.

• PSO3 Introducing scientific cognition, critical thinking, analysis using in age computational tools to develop competence for academic research and industry at par with the global scenario.

• PSO4 Making students aware to the needs of a society for constructive contribution towards its sustainable growth and development of products of high socio-economic importance such as improved crops, vaccines, diagnostic tools, improve microbial strains for enhancing the production of high value compounds.

• PSO5 Understand the social aspects, ethical concerns, issues of intellectual properties and policies of the Biotechnology industry along with evaluating the ethical, legal and social issues pertaining to use of biological systems.

Two-Year Post-graduate Program

Course and Credits Distribution of Two years/One Year PG/Master's Degree Program with Entry & Exit Option

Faculty of Science & Technology

Year / level	Sem.	Major subject		RM	OJT /FP	RP	Credits	Degree
		DSC Core Mandatory	DSE (Elective)					
First year 6.0	I	3(4) +2=14	4	4			22	PG Diploma (after 3 years degree)
	II	3(4) +2=14	4		4		22	
Cum. Cr. For PG Diploma		28	08	4	4		44	
Exit option with Post-graduate Diploma (44 credits) after first year or two semester with completion of courses equivalent to 44 credits								
Second Year 6.5	III	3(4)+2=14	4			4	22	PG Degree after 3 years UG or PG Degree after 4 years UG
	IV	3(4)=12	4			6	22	
Cum. Cr. For 1 year PG Degree		26	8			10	44	
Cum. Cr. For 2 years PG Degree		54	16	4	4	10	88	
2 Years -4 sem.PG Degree (88 credits) after three year UG Degree or 1 Year -2 sem. PG Degree (44 credits) after four year UG degree								
8.0			Course work Min.12 credits 3(4)		Training in teaching /education/pedogogy:4		16+ Ph.D. Work	Ph.D.in subject

Note- DSC-is based on specialization

ABBREVIATION:

Major – Comprising Mandatory –is based on specialization

DSE- Discipline Specific Elective

OJT – On-the- Job Training

FP – Field Project (Corresponding to the Major (Core) Subject

RP – Research Project (Corresponding to the Major (Core) Subject

Internship/Apprenticeship - (Corresponding to the Major (Core) Subject

AS PER NEP 2020

Illustrative Credit distribution structure for Two Years/One Year Programme with Multiple Entry and Exit options –

(Discipline Specific Core in Biotechnology)

Class: M.Sc. Second Year (Semester III) Subject: Biotechnology

Course type	Course Code	Course Name	Teaching Scheme (Hrs./ week)		Credits Assigned Training Hrs/week		Total credits
			Theory	Practical	Theory	Practical	
Major Mandatory DSC	BIOT/MJ/600-T	**Bioprocess Engineering**	2	-	2	-	4+4+4 +2=14
	BIOT/MJ/600-P	Lab Course Based On BIOT/MJ/600- T	-	4	-	2	
	BIOT/MJ/601-T	**Gene Expression & Genetic Engineering**	2	-	2	-	
	BIOT/MJ/601-P	Lab Course Based On BIOT/MJ/601- T	-	4	-	2	
	BIOT/MJ/602-T	**Bioinstrumentation**	2	-	2	-	
	BIOT/MJ/602-P	Lab Course Based On BIOT/MJ/602- T	-	4	-	2	
	BIOT/MJ/603-T	Skills In Biotechnology III (Regulatory Affairs in Biotechnology)	2	-	2	-	
DSE (Choose any one from pool of courses)	BIOT/DSE/604-AT	**Plant Biotechnology-II**	2	4	2	2	4
	BIOT/DSE/604-AP	Lab Course Based on Plant Biotechnology-II					
	BIOT/DSE/604-BT	**A I and System Biology**					
	BIOT/DSE/604-BP	Lab Course Based on Plant AI and system Biology					
	BIOT/DSE/604-CT	**Advanced Techniques in Biotechnology**					
	BIOT/DSE/604-CP	Lab Course Based on Advanced Techniques in Biotechnology					
	BIOT/DSE/604-DT	**Entrepreneurship in Biotechnology**					
	BIOT/DSE/604-DP	Lab Course Based on Entrepreneurship in Biotechnology					
	BIOT/DSE/604-E	**(MOOC Course) Or any Online certification course from NPTEL /SWAYM /MOOC of equivalent credits { with biology basis }**					
RP	BIOT/ RP /605	**Research Project Stage I**	-	8	-	4	4
			12	20	12	10	**22 credits**

EXPLAINATION OF CODE:

BIOT=BIOTECHNOLOGY, MJ=Discipline specific core, Major/Mandatory; RP= RESEARCH project , T= THEORY, P= PRACTICATS ; 600-649- COURSE CODE AS PER GUTDELTNES of NEP- 2020

Illustrative Credit distribution structure for Two Years/One Year Programme with Multiple Entry and Exit options –
(Discipline Specific Core in Biotechnology)
Class: M.Sc. Second Year (Semester: IVth) Subject: Biotechnology

Course type	Course Code	Course Name	Teaching Scheme (Hrs./ week)		Credits Assigned Training Hrs/week		Total credits
			Theory	Practical	Theory	Practical	
Major Mandatory DSC	BIOT/MJ/650-T	Industrial Technology	2	-	2	-	4+4+4= 12
	BIOT/MJ/650-P	Lab Course Based On BIOT/MJ/650- T	-	4	-	2	
	BIOT/MJ/651-T	rDNA technology	2	-	2	-	
	BIOT/MJ/651-P	Lab Course Based On BIOT/MJ/651- T	-	4	-	2	
	BIOT/MJ/652-T	Bioinformatics	2	-	2	-	
	BIOT/MJ/652-P	Lab Course Based On BIOT/MJ/652- T	-	2	-	2	
DSE (Choose any one from pool of courses)	BIOT/DE/653-AT	**Environmental Biotechnology**	2	4	2	2	4
	BIOT/DE/653-AP	Lab Course Based On Environmental Biotechnology					
	BIOT/DE/653-BT	**Animal Biotechnology-II**					
	BIOT/DE/653-BP	Lab Course Based Animal Biotechnology-II					
	BIOT/DE/653-CT	**Synthetic Biology**					
	BIOT/DE/653-CP	Lab Course Based Synthetic Biology					
	BIOT/DE/653-DP	**Pharmaceutical Biotechnology**					
	BIOT/DE/653-DT	Lab Course Based Pharmaceutical Biotechnology					
	BIOT/DSE/653-E	**(MOOC Course) Or any Online certification course from NPTEL /SWAYM /MOOC of equivalent credits { with biology basis }**					
RP	BIOT/ RP /654	Research Project Stage II	-	12	-	6	6
			13	18	10	9	**22 credits**

EXPLAINATION OF CODE:
BIOT=BIOTECHNOLOGY, MJ=Discipline specific core, Major/Mandatory, RM= RESEARCH project , T= THEORY, P= PRACTICATS , 650-655- COURSE CODE AS PER GUTDELTNES of NEP- 2020

Type of Course :	DSC Major / Mandatory Major course
Course Code:	BIOT/MJ/600-T
Course Title :	**Bioprocess Engineering**
Teaching method:	Classroom lectures
Teaching Scheme :	(Hrs./ Week) 2
Contact Hours:	30
Credits Assigned :	2

Learning Objectives of the Course:

--Course Objectives:

1. Understand the basic concepts and principles of bioprocess engineering
2. Analyze and design bioreactors and related equipment.
3. Apply mass and energy balance principles to bioprocesses.
4. Understand microbial kinetics and metabolic pathways.
5. Explore downstream processing techniques for product recovery and purification.

Course Outcomes (COs) :

After completion of the course, students will be able to -

1. Explain the principles and scope of bioprocess engineering and its significance in industrial applications.
2. Design and understand different types of bioreactors (batch, fed-batch, continuous) and understand the principles behind their scale-up.
3. Apply mass and energy balance principles to analyze and solve problems in bioprocess engineering.
4. Understand and model microbial growth kinetics, substrate utilization, and product formation kinetics in bioprocesses.
5. Explain and apply various downstream processing techniques for the recovery and purification of bioproducts.

Module No.	Topics / actual contents of the syllabus	Contact Hours
I	**Basics of Bioprocess Engineering** Introduction to Biochemical Engineering Calculations - Definition and scope of bioprocess engineering. - Overview of industrial bioprocesses and their applications. - History and evolution of bioprocess engineering. Mass and energy balances in bioprocesses, flow sheet and process calculations, Case studies and examples of mass and energy balances Overview of metabolic pathways; Metabolic stoichiometry of growth and product formation, material balance and energy balance **Microbial Growth Kinetics:** Different modes of operation of reactors, batch, continuous and fed batch, Kinetics of growth in Batch culture and continuous culture w.r.t. substrate utilization, specific growth rate, substrate utilization; steady state in a	**10 Hrs**

	chemostat; Fed batch fermentations; yield of biomass, product; calculations for productivity.	
II	**Bioreactors :** **Design of a basic fermenter:** Design features, individual parts, baffles, impellers, foam separators, sparger, culture vessel, cooling and heating devices. Calculations for designing a bioreactor. **Instrumentation and control of bioprocesses** (Physical and chemical sensors for the medium and gases., online sensors for cell properties, off-line analytical methods Biosensors , computer control of fermentation process) **Mass Transfer in reactors:** Aeration /Agitation its importance; critical oxygen concentration;, mass transfer and diffusion, Gas - liquid exchange (two film theory for mass transfer) and O_2 transfer, methods for determination of k_la , heat transfer (a brief account). **Media and air sterilization:** introduction and the kinetics of death of microorganisms; batch and continuous sterilization of media, air sterilization, various type of sterilization equipments, sterilization of media by membrane filters, Sterilization of Bioreactors-*ex-situ* and *in-situ,* Merits and demerits of each	**10 Hrs**
III	**Development of Fermentation process : concept to commissioning** Screening and Isolation of microorganisms, Strain improvement of the selected organisms, special example of strain improvement program (penicillin production). Designing of fermentation media for lab scale experiments to industrial process; inoculum development and production; inoculum development strategies and procedure; storage of cultures for repeated fermentations. Inoculum development and production including inoculums development strategies and procedure; Scaling up of process from shake flask to industrial fermentations (Economic considerations) Scale up of Bioreactors **Down stream processing :** Cell separation techniques (centrifugation, filtration). Product recovery methods (extraction, precipitation). Purification techniques (chromatography, electrophoresis). Case studies in downstream processing.(Product recovery trains)	**10 Hrs**

Text Books:

1. Biochemical Engineering Fundementals,- Baily & Ollis Tata Mcgraw hill ,New york
2. Principles of Fermentation technology, -Stanbury & whittekar Butterworth-Heinemann.
3. Biotechnology, A text book of Industrial Microbiology, Creuger &

Creuger Sinaeur Associates

4. Basic Biotechnology, 2nd Ed. Colin Ratledge and Bjorn Kristiansen,Cambridge University Press

Reference Books

1. Manual of Industrial Microbiology and Biotechnology 2nd Edition, Davies,J.E and Demain ASM, Publications
2. 2. Industrial Microbiology -L.E.Cassida, Wiley Eastern
3. 3. Metaboloic Engineering. Principles and Methodologies., Stephanopoulos,G.,Neilson,J, and Aristodou,A . Academic Press, San Diego
4. 4. Biotechnology: A comprehensive treatise H.J.Rehm &Reed G,VCH
5. 5. Biochemical Reactors Atkinson B Pion Ltd, London
6. 6. Energetics of Microbial Growth, Battley, E.H. John Wiley &Sons
7. 11. Bioprocess Engineering Principles, Doran P.M.,-Academic Press, London
8. 12. Basic Bioreactor Design. Van't Riet,K. and Tramper ,J. Marcel Dekker, New York
9. 13. Seperation Process in Biotechnology, Asenjo, J.A., ed. Marcel Dekkar, New York

Scope:

This course introduces the principles and applications of bioprocess engineering. Students will learn about the design, analysis, and control of biological processes used in the production of biopharmaceuticals, biofuels, and other bioproducts. Emphasis is placed on understanding the fundamentals of microbiology, biochemistry, and engineering principles as they apply to bioprocessing.

Type of Course :	DSC Major / Mandatory Major course
Course Code:	BIOT/MJ/600-P
Course Title :	**Bioprocess Engineering**
Teaching method:	Classroom lectures
Teaching Scheme :	(Hrs./ Week) 4
Contact Hours:	60
Credits Assigned :	2

ModuleNo.	Topics / actual contents of the syllabus
I	Random and strategic screening for a PRIMARY/ SECONDARY metabolite **(screening for citric acid producing organisms /crowded plate technique for antibiotic producing organisms)**
II	Random and strategic screening for a SECONDARY metabolite **(screening for citric acid producing organisms /crowded plate technique for antibiotic producing organisms)**
III	Determination of TDP & TDT of *E .coli* / industrially important bacterial isolate
IV	Determination of TDP & TDT of *E .coli* / industrially important bacterial isolate
V	Determination of Growth curve of yeast/bacteria to Bacterial growth kinetics and compute growth rate & growth yield
VI	Media balancing experiments: carbon and nitrogen as variables
VII	Alcohol Fermentation and its downstream processing.
VIII	K_La determination

Type of Course :	DSE Course Theory
Course Code:	BIOT/MJ/601-T
Course Title :	**Gene Expression and Genetic Engineering**
Teaching method:	Classroom lectures
Teaching Scheme :	(Hrs./ Week) 2
Contact Hours:	30
Credits Assigned:	2

Course Description:

This course provides an in-depth understanding of regulation of gene expression and principles and methods in genetic engineering, vectors in gene cloning, transformation in higher organisms, throws light on various molecular tools used for genetic manipulation

Learning Objectives of the Course:

1. To introduce the foundational concepts and methodologies Gene Expression and Genetic Engineering
2. To make students to understand the regulation of catabolic and anabolic gene expression.
3. To make the student familiar with the currently used techniques to manipulate/ analyse DNA, RNA and proteins.

Course Outcomes (COs):

After completion of the course, students will be able to -

1. Students will acquire the knowledge of the role of enzymes and vectors responsible for gene manipulation, transformation and genetic engineering
2. Gain insights of mechanism of gene expression and regulations.
3. Students will be able to gain hands on experience in gene cloning, protein expression and purification

ModuleNo.	Topics / actual contents of the syllabus	Contact Hours
I	**Unit I: Regulation of Gene Expression (1 Credit)** **Regulation of gene expression:** operon concept- *lac, trp, ara, gal*, Factors and elements involved regulation: GTF, TAF, TF, activators and repressor, co-repressor, combinatorial gene regulation, synergistic gene regulation stringent response and regulation by small molecules such as ppGpp, **DNA binding motifs:** Helix Turn Helix, Zinc finger motif, Basic Zipper, Helix Loop helix, **DNA-protein interaction studies:** DNA foot printing assay, Chip, EMSA. **Epigenetic gene regulation:** Role for DNA modification in control of gene expression, Mechanisms of Chromatin remodeling with reference to activation or repression of a region on chromosome, Methylation and Demethylation, Histone deacetylation, acetylation, Insulators, genetic Imprinting.	**12 Hrs**
II	**Unit II: Tools of genetic engineering (0.5 Credit)** **Introduction** of genetic engineering, its applications and impact on	**8 Hrs**

	modern society, ELSI. **Restriction Endonucleases**: their properties and specificities, applicability. **Modification Enzymes**: DNA Ligase, S1 Nuclease, Bal31 Nuclease, Mung bean nuclease, Exonulease III, Terminal DNA Transferase, T4 DNA Polymerase, DNA Polymerase I, DNA polymerase II, DNA Polymerase III, Klenow fragment, Taq DNA polymerase, *pfu* polymerase, T7 DNA polymerase, Sequenase, Polynucleotide Kinase, Phosphatases, Reverse Transcriptase, RNaseA, RNaseH, Linkers and adaptors. **Promoters,** plac, ptrp, pBAD, para, pgal, phage promoters, sp6, T3, and T7 promoters in addition to lambda pR, pL, pR' promoters for expression, hybrid promoters (ptac, ptrc,),	
III	**Unit III: Vectors in Genetic engineering (structural organization, general features, regulatory features and applications) (0.5 Credit)** **Plasmids;** pBR322 and pUC19, Bacteriophages; Lambda vectors; Insertion and Replacement vectors; M13 vectors; and Phagemids; Bluescript vectors, Cosmids; c2XB **Artificial chromosome vectors** (YACs; BACs, PACs &HAC); **Expression vectors**: Principles for maximizing gene expression vectors; pET-based vectors; **Protein purification;** His-tag; GST-tag; MBP-tag, FLAG, Intein-based vectors; **Protein expression systems:** bacterial, yeast, insect, mammalian and plant systems, cell free systems. **Protein-protein interactions:** Co-immunoprecipitation (Co-IP), Pull down assay, two hybrid system, FRET, and Phage display technique. **Mammalian expression and viral vectors**; Baculovirus and Adeno virus vectors, Lentiviral vectors, plant based vectors: Ti plasmid, binary vectors, yeast vectors, shuttle vectors. **Specialized vectors**; Litmus vectors, GATEway vectors, and Pin point vectors. **Methods of Insertion of foreign DNA into host cells**; transformation, electroporation, transfection	**10 Hrs**

Reference Books:

1. " Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick,(2018). Lewin's GENES XII, 12th edition, Jones and Bartlett learning publication, Burlington, MA.
2. Robert Weaver, Molecular biology, 5th edition, McGraw-Hill publication USA.
3. Nicholl, Desmond S. T. An Introduction To Genetic Engineering 4 Revised edition, Published by Cambridge University Press, 2023.
4. Brown, T. A. (2023). Genomes (5 ed.). CRC press, Boca Raton
5. Ernst-L. Winnacker, From genes to clones: Introduction to gene technology. Weinheim publication; New York, NY : VCH, 1987
6. Analysis of Genes and Genomes by Reece, Richard J, 2004, John Wiley & Sons Inc.USA
7. Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). Principles of Gene Manipulation: an Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications.
8. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Pres
9. " Bernard R. Glick, Jack J. Pasternak, and Cheryl L. Patten. (2003) Molecular Biotechnology: principles and applications of recombinant DNA.
10. Freifelder, D. 1990. Essentials of Molecular Biology. Narosa Publishing House, NewDelhi.
11. Lodish, H., Berk,A., Matsudaira,P., Baltimore, D., Zipursky, S.L and Darnel, J. 1995.

Review Articles:

1. " Bulcha, J.T., Wang, Y., Ma, H. et al. Viral vector platforms within the gene therapy landscape. Sig Transduct Target Ther 6, 53 (2021).
2. Rao VS, Srinivas K, Sujini GN, Kumar GN. Protein-protein interaction detection: methods and analysis. Int J Proteomics. 2014;2014:147648.
3. " Stephens KE, Miaskowski CA, Levine JD, Pullinger CR, Aouizerat BE. Epigenetic regulation and measurement of epigenetic changes. Biol Res Nurs. 2013 Oct;15(4):373-81.

Online Resources :

1. https://www.sigmaaldrich.com/IN/en/technical-documents/technical-article/protein-biology/protein-expression/protein-expression-systems
2. https://www.thermofisher.com/in/en/home/references/gibco-protein-expression-basics.html
3. https://archive.nptel.ac.in/content/storage2/courses/102103045/download/mod4.pdf

Scope:

This course provides a comprehensive overview of regulation of gene expression and genetic engineering, emphasizing both theoretical knowledge and practical applications, preparing students for research and careers in industry.

Type of Course :	DSE Course Theory
Course Code:	BIOT/MJ/601-P
Course Title :	**Gene Expression and Genetic Engineering**
Teaching method:	Practicals
Teaching Scheme :	(Hrs./ Week)4
Contact Hours:	60
Credits Assigned :	2

Learning objective of the coursr:

1. To introduce hand-on knowledge and skill required for genetic manipulations.
2. To understand role of different enzymes and vectors in genetic engineering.
3. To understand gene transfer methods.
4. To understand different online tools for genetic engineering technique.

Course Outcomes (COs) :

After completion of the course, students will be able to -

1. Students will gain hands-on knowledge and acquire adequate skill required for genetic manipulations
2. Students will acquire the knowledge of the role of enzymes and vectors responsible for gene manipulation, transformation and genetic engineering.
3. Students will acquire detailed knowledge of gene transfer methods and identifying suitable hosts for cloning.
4. Students will able to design a restriction map using online tools.

Module No.	**Topics / actual contents of the syllabus**
I	Isolation of genomic DNA from animal /plant sources/ bacteria
II	Isolation of plasmid from bacillus sp.
III	To study the plasmid restriction digestion.
IV	To prepare the restriction map using online software tools
V	DNA ligation –ligase reaction, testing efficiency of ligation.
VI	Transformation in *E.coli* with standard plasmids, calculation of transformation efficiency
VII	Preparation of competent cells
VIII	Study of conjugation in *E.coli* and score for a marker
IX	To study generalized transduction in *E.coli* using P1 phage
X	Phage titration with P1 phage
XI	Gene expression in *E.coli* and yeast-blue white
XII	Electrocution to purify the DNA
XII	Activities: study visits to Industry and Research Institute

References:

1. Sambrook, I., Fritsch, E.F. and Maniatis, T. (2001). Molecular Cloning 1, 2, 3 - A Laboratory Manual (3rd ed). USA: Cold Spring Laboratory Press.
2. Brown, T.A. (1998). Molecular Biology Lab Fax 11 Gene Analysis. London: Academic Press.
3. Berger, S.L. and Kimmel, R. (1987). Guide to Molecular Cloning Techniques. New York: Academic Press, Inc.
4. Laboratory Manual for GENETIC ENGINEERING 1st Edition (2009) S. JOHN VENNISON PHI Learning.

Type of Course :	DSC Major / Mandatory Major cours
Course Code:	BIOT/MJ/602-T
Course Title :	**Bioinstrumentation**
Teaching method:	Classroom lectures
Teaching Scheme :	(Hrs./ Week) 2
Contact Hours:	30
Credits Assigned :	2

Learning Objectives of the Course:

1. To introduce the student to the variety of biophysical and biochemical techniques.
2. To make students to understand Biomolecule Purification and microscopic imaging techniques
3. To introduce the student to the variety of spectroscopic techniques of molecule characterization.
4. To make them familiar with various approaches of analytical techniques

Course Outcomes (COs) :

After completion of the course, students will be able to -

1. Understand the variety of biophysical and biochemical techniques.
2. Understand Biomolecule Purification and microscopic imaging techniques.
3. Understand the variety of spectroscopic techniques of molecule characterization.
4. Study various approaches of analytical techniques.

4.

Module No.	Topics / actual contents of the syllabus	Contact Hours
I	**Chromatographi techniques:** The Partition Coefficient, Column Chromatography, Chromatography Components for Protein Purification (stationary phase, column, mobile phase and, injector system, detector). Affinity Chromatography, Ion Exchange Chromatography, Size-Exclusion Chromatography (SEC), Hydrophobicity Interaction Chromatography (HIC). **ELECTROPHORETIC TECHNIQUES:** General Principles, SUPPORT MEDIA AND BUFFERS: Agarose Gels, Polyacrylamide Gels, ELECTROPHORESIS OF PROTEINS: SDS-Polyacrylamide Gel Electrophoresis, Native (Buffer) Gels, Gradient Gels, Isoelectric Focussing Gels, Two-Dimensional Polyacrylamide Gel Electrophoresis, Cellulose Acetate Electrophoresis, **CAPILLARY ELECTROPHORESIS:** High-Voltage Injection, Pressure Injection. **FLOW CYTOMETRY:**INSTRUMENTATION: Operating System (Fluidic and optical System), Signal Detection and Processing. **FLUORESCENCE-ACTIVATED CELL SORTING (FACS), APPLICATIONS:** **MICROSCOPY**: **THE LIGHT MICROSCOPE:** Compound	**10 Hrs**

	Microscopes, Stereomicroscopes, Phase contrast, Differential interference contrast (DIC), Fluorescence microscopy, Laser-Scanning Confocal Microscopes, Spinning-Disc Confocal Microscopes, Multiple-Photon Microscopes. **THE ELECTRON MICROSCOPE**: Principles, Preparation of Specimens,	
II	**SPECTROSCOPIC TECHNIQUES:** Properties of Electromagnetic Radiation, Polarised Light, Lasers. Chromophores, **ULTRAVIOLET AND VISIBLE LIGHT SPECTROSCOPY:** Principles (Quantification of Light Absorption, Deviations from the Beer–Lambert Law, Absorption or Light Scattering, Instrumentation, Applications (Qualitative and Quantitative Analysis, Difference Spectra, Spectrophotometric and Colorimetric Assays). **CIRCULAR DICHROISM SPECTROSCOPY:**Principles (Polarimetry and Optical Rotatory Dispersion, Circular Dichroism, Instrumentation, Applications. INFRARED AND RAMAN SPECTROSCOPY:Principles , Instrumentation, Applications. **FLUORESCENCE SPECTROSCOPY:** Principles, Instrumentation, Applications (Intrinsic Protein Fluorescence, Extrinsic Fluorescence), Quenching, Fluorescence Resonance Energy Transfer (FRET), Bioluminescence Resonance Energy Transfer (BRET), **ATOMIC SPECTROSCOPY: ICP-OES** (Inductively coupled plasma optical emission spectroscopy) Principles, Instrumentation, Applications	**10 Hrs**
III	**TECHNIQUES TO INVESTIGATE THE THREE-DIMENSIONAL STRUCTURE** **Nuclear Magnetic Resonance (NMR) Spectroscopy**, Molecular Structure Determination of Small Molecules, Magnetic Resonance Imaging (MRI), X-Ray Diffraction. **MASS SPECTROMETRIC TECHNIQUES:** Components of a Mass Spectrometer, **IONISATION:** Electron Impact Ionisation (EI), Chemical Ionisation (CI), Fast Atom Bombardment (FAB), Electrospray Ionisation (ESI), Matrix-Assisted Laser Desorption Ionisation (MALDI), **MASS ANALYSERS**: Quadrupole Mass Spectrometer, Ion-Trap Mass Spectrometer, Time-of-Flight (TOF) Mass Spectrometer, Fourier Transform Ion Cyclotron Resonance Mass Spectrometer, Orbitrap Mass Spectrometer. **DETECTORS**: Electron Multiplier and Conversion Dynode,	**10 Hrs**

Text Books:

1. Beynon R. and Easterby J. S. (2003) Buffer Solutions (The Basics), Taylor &Francis, New York, USA.
2. Boyer R.F. (2011) Biochemistry Laboratory: Modern Theory and Techniques, 2nd Edn., Prentice Hall, Upper Saddle River, NJ, USA.
3. Lesk A.M. (2016) Introduction to Protein Science: Architecture, Function, and

Genomics, 2nd Edn., Oxford University Press, Oxford, UK
4. Simpson R.J., Adams P.D. and Golemis E.A. (2008) Basic Methods in Protein Purification and Analysis: A Laboratory Manual, CSH Press, New York, USA
5. **James P. Landers**(2007)Handbook of Capillary and Microchip Electrophoresis and Associated Microtechniques 3rd editionCRC Press
6. Watson J.V. (2004) Introduction to Flow Cytometry, Cambridge University Press, Cambridge, UK.
7. Walker S.W, Beckett G.I., Rae P., and Ashby P. (2013) Lecture Notes on Clinical Biochemistry, 9th Edn., Blackwell Science, Oxford, UK.
8. Magdeldin S. (2012) Gel Electrophoresis: Principles and Basics, InTech Publishers, Rijeka, Croatia
9. Spector D.L. and Goldman R.D. (2006) Basic Methods in Microscopy, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY, USA.
10. Schuck P., Zhao H., Brautigam C.A. and Ghirlando R. (2015) Basic Principles of Analytical Ultracentrifugation, CRC Press, Boca Raton, FL, USA.

Reference Books:

1. Beynon R. and Easterby J. S. (2003) Buffer Solutions (The Basics), Taylor &Francis, New York, USA.
2. Boyer R.F. (2011) Biochemistry Laboratory: Modern Theory and Techniques, 2nd Edn., Prentice Hall, Upper Saddle River, NJ, USA.
3. Lesk A.M. (2016) Introduction to Protein Science: Architecture, Function, and Genomics, 2nd Edn., Oxford University Press, Oxford, UK
4. Simpson R.J., Adams P.D. and Golemis E.A. (2008) Basic Methods in Protein Purification and Analysis: A Laboratory Manual, CSH Press, New York, USA
5. **James P. Landers**(2007)Handbook of Capillary and Microchip Electrophoresis and Associated Microtechniques 3rd editionCRC Press
6. Watson J.V. (2004) Introduction to Flow Cytometry, Cambridge University Press, Cambridge, UK.
7. Walker S.W, Beckett G.I., Rae P., and Ashby P. (2013) Lecture Notes on Clinical Biochemistry, 9th Edn., Blackwell Science, Oxford, UK.
8. Magdeldin S. (2012) Gel Electrophoresis: Principles and Basics, InTech Publishers, Rijeka, Croatia
9. Spector D.L. and Goldman R.D. (2006) Basic Methods in Microscopy, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, NY, USA.
10. Schuck P., Zhao H., Brautigam C.A. and Ghirlando R. (2015) Basic Principles of Analytical Ultracentrifugation, CRC Press, Boca Raton, FL, USA.

Scope:

This course introduces the principles and applications of various instruments use for biomolecule purification and characterizatio. Students will learn about the , analysis, and qualitative and quanitative analysis of various molecules.

Type of Course :	DSC Major / Mandatory Major course
Course Code:	BIOT/MJ/602-P
Course Title :	**Bioinstrumentation**
Teaching method:	**Practical**
Teaching Scheme :	(Hrs./ Week) 4
Contact hours	60
Credits Assigned :	2

Learning Objectives of the Course:

5. To gain hands-on skill on variety of biophysical and biochemical techniques.
6. To make students to understand Biomolecule Purification and microscopic imaging techniques.
7. To introduce the student to the variety of spectroscopic techniques of molecule characterization.
8. To make them familiar with various approaches of analytical techniques

Course Outcomes (COs) :

After completion of the course, students will be able to -

5. Understand the variety of biophysical and biochemical techniques.
6. Understand Biomolecule Purification and microscopic imaging techniques.
7. Understand the variety of spectroscopic techniques of molecule characterization.
8. Study various approaches of analytical techniques.

Module No.	Topics / actual contents
1	Preparation of absorbance curve
2	Adsorption column chromatography
3	Paper Chromatography of amino acids- Ascending and Descending methods.
4	Observation of specimen through Steriomicroscope/ Dark field/ phase contrast microscope.
5	Thin layerchromatography
6	Paper electrophoresis of Amino Acids
7	Separation of bromophnol blue and xylenecyn by Agarose gel electrophoresis
8	Agarose gel electrophoresis of DNA
9	Determination of molecular weight by native and SDS PAGE
10	Gel documentation
11	Immunoelectrophoresis- serum proteins
12	Demonstration on protein purifictin system/ HPLC
13.	Activities: study visits to Industry and Research Institute

Type of Course :	DSC Major / Mandatory Major course
Course Code:	BIOT/MJ/603-T
Course Title :	**Skills In Biotechnology III** (Regulatory Affairs in Biotechnology)
Teaching method:	Classroom lectures
Teaching Scheme :	(Hrs./ Week) 2
Contact Hours:	30
Credits Assigned:	2

Course Description:

This course aims to provide an in-depth understanding of regulatory affairs in biotechnology with a focus on both global and Indian perspectives. The course covers the regulatory frameworks, guidelines, and best practices necessary for the development, approval, and commercialization of biotechnological products. It includes topics on regulatory agencies, compliance requirements, and ethical considerations.

Learning Objectives of the Course:

6. To understand the regulatory frameworks governing biotechnology products globally and in India.
7. To gain knowledge of the processes involved in obtaining regulatory approvals for biotechnological products.
8. To develop skills in preparing regulatory submissions and ensuring compliance with regulatory requirements.

Course Outcomes (COs):

After completion of the course, students will be able to -

5. To develop skills in preparing regulatory submissions and ensuring compliance with regulatory requirements.
6. Students will acquire the skills to prepare and submit regulatory documents for the approval of biotechnological products.
7. Students will be able to identify and address compliance and ethical issues in biotechnology research and development.

ModuleNo.	Topics / actual contents of the syllabus	Contact Hours
I	**Unit I: Global Regulatory Frameworks (1 Credit)** ***Introduction to Regulatory Affairs in Biotechnology:*** Definition and Importance, Historical Development. ***Global Regulatory Agencies:*** Overview of Major Regulatory Agencies: FDA (USA), EMA (Europe), PMDA (Japan), CFDA (China), Roles and Responsibilities ***Regulatory Pathways:*** Drug and Biologics Development Pathways, Medical Devices and Diagnostics Pathways, Biosimilars and Biogenerics. ***Regulatory Guidelines and Standards:*** ICH Guidelines (International Council for Harmonisation) ISO Standards (International Organization for Standardization) ***Case Studies:*** Successful Regulatory Approval of a Biotechnological Product (Global Perspective)	**15 Hrs**

	Challenges Faced in Global Regulatory Compliance	
II	**Unit II: Indian Regulatory Frameworks (0.5 Credit)** ***Overview of Indian Regulatory Agencies:*** Central Drugs Standard Control Organization (CDSCO), Department of Biotechnology (DBT), Indian Council of Medical Research (ICMR). ***Indian Regulatory Pathways:*** Drug and Biologics Approval Processes, Medical Devices and Diagnostics Approval Processes, Biosimilars and Biogenerics in India ***Regulatory Guidelines and Standards in India:*** Schedule Y of Drugs and Cosmetics Act, National Guidelines for Stem Cell Research,Indian Pharmacopoeia ***Case Studies:*** Regulatory Approval Process for a Biotechnological Product in India Comparison of Global vs. Indian Regulatory Approval Processes	**7.5 Hrs**
III	**Unit III: Compliance and Ethical Considerations (0.5 Credit)** ***Compliance Requirements:*** Good Manufacturing Practice (GMP), Good Laboratory Practice (GLP), Good Clinical Practice (GCP) ***Regulatory Submission and Documentation:*** Common Technical Document (CTD), eCTD (Electronic Common Technical Document), Dossier Preparation ***Ethical Considerations in Biotechnology:*** Ethical Guidelines for Biotechnology Research and Development, Regulatory Requirements for Human and Animal Subjects, ***Future Trends in Regulatory Affairs:*** Emerging Regulatory Challenges, Role of Artificial Intelligence and Digital Health in Regulatory Affairs. ***Case Studies:*** on Ethical Dilemmas in Biotechnology	7.5 Hrs

Text Books:

Reference Books:

1.Fundamentals of International Regulatory Affairs, Fifth Edition, Publisher : Regulatory Affairs Professionals Society (RAPS)

2.Rodney, and M. Gibaldi. 2013. Biotechnology and Biopharmaceuticals Publisher: John Wiley & Sons, Inc.

Review Articles:

1. Regulatory Guidelines for Approval of Biosimilars in India, Europe, Brazil and China: A Comprehensive Overview-International Journal of Pharmacy and Pharmaceutical Sciences
2. The Coordinated Framework for the Regulation of Biotechnology Plain Language Information on the Biotechnology Regulatory System. 2023.- The U.S. Department of Agriculture, The U.S. Environmental Protection Agency, The U.S. Food and Drug Administration.

Scope:

This course will provide a comprehensive understanding of the regulatory landscape in biotechnology, preparing students for careers in regulatory affairs and compliance within the biotech industry.

Type of Course :	DSE Major / Elective course
Course Code:	BIOT/DSE/604-AT
Course Title :	**Plant Biotechnology-II**
Teaching method:	Classroom lectures
Teaching Scheme :	(Hrs./ Week)2
Contact Hours:	30
Credits Assigned :	2

Learning course objective :

1. To understand about various gene transfer methods
2. To gain knowledge about analysis of transgenic plants.
3. To make student aware about Recent trends in Plant Biotechnology

Course Outcomes (COs):

After completion of the course, students will be able to -

4. understand about various gene transfer methods in plants.
5. Understand about analysis of transgenic plants.
6. Aware about Recent trends in Plant Biotechnology

Module No.	Topics / actual contents of the syllabus	Contact Hours
I	**Plant Genetic Transformation** **Vector mediated gene transfer** *Agrobacterium* mediated plant transformation: *Agrobacterium tumefaciens*; Organization of Ti plasmid, T DNA transfer and integration, binary cloning vector, cointegrate cloning vector, advantages and disadvantages. Plant viral vectors mediated plant transformation: CaMV, TMV. **Direct or vector less gene transfer** **Physical methods:** Microinjection, electroporation, Liposome fusion, silicon carbide fibres and biolistic gun. **Chemical methods:** Polyethylene glycol (PEG) mediated, diethylaminoethyl (DEAE) dextran mediated. **Other DNA Transfer Methods and Chloroplast transformation** Marker genes, Promoters and terminators, Marker free plant; In planta transformation methods - Floral dip method, Chloroplast transformation, Transgenes stability, expression and gene silencing.	12

II	**Analysis and application of transgenics:** **Analysis** of transgenic plants - presence, expression - Polymerase chain reaction, Southern blot hybridization, Northern blot, Western blot, RT-PCR and ELISA. Inheritance of transgenes -Genetic analysis -T1 and T2 generation. **Applications:** **Yield and Quality Improvement** Engineering seed storage proteins - cereals and pulses, manipulation of fatty acid and starch biosynthesis. Enhancement of shelf life -fruits and vegetables, Modification of flower color. **Agronomic Traits** Biotic stress resistance: Insect (Pest) resistance, virus resistance. Abiotic stress resistance: Draught tolerance, herbicide tolerance. **Other traits** Bioremediation, phytoremediation, secondary metabolites, recombinant vaccines, plantibodies and therapeutic compounds. Molecular pharming.	10
III	**Recent trends in Plant Biotechnology** National and Global status of transgenic plants, GMOs and its concern, GM Cotton, GM Mustard, GM Brinjal. Clustered regularly interspaced short palindromic repeats **(CRISPR-cas9),** Transcription activator -like effector nucleases **(TALENs),** Zinc finger nucleases **(ZFNs),** Meganucleases **(MNs).**	08

Text Books:

1. Singh, B. D. 2007. Biotechnology, Kalyani Publications, New Delhi
2. 2. Stanton B. Gelvin and Robert A. Schilperoort, 1998. (II Edn). Plant Molecular Biology Manual –Klumer academic publishers.
3. 3. Paul Christou and Harry Klee, 2004 Handbook of Plant Biotechnology, 2 volume set, Wiley publisher, 1488 pages.
4. 4. Tzfira, Tzvi; Citovsky, Vitaly, 2008. Agrobacterium: From Biology to Biotechnology. (Eds.). Springer publication. ISBN: 978-0-387-72289-4 750 pages
5. 5. Brown, T.A. 2010. Gene cloning and DNA analysis. An Introduction, (VI Edn.) Blackwell Publishing
6. 6. Biotechnology by Dr. U Satyanarayana
7. 7. Slater, A., Nigel, S and Fowler. M. 2003. Plant Biotechnology: The Genetic Manipulation of Plants. Oxford Publications
8. 8. Rainer Fischer and Stefan Schillberg, 2004, Molecular Farming- Plant made pharmaceuticals and technical proteins., WILEY-VCH Verlag publisher
9. 9. Kirsi-Marja Oksman-Caldentey, Wolfgang Barz, 2002.Plant Biotechnology and Transgenic Plants
10. CRC Press, 720 pages.
11. 10. Ian S. Curtis, 2004, Transgenic crops of the world, essential protocols. 454 pages. Kluwer Academic Publisher
12. 11. Adrian Slater, Nigel Scott and Mark Fowler, 2003, Plant Biotechnology- The genetic manipulation of plants, Oxford University Press. 368 pages
13. 12. Sambrook J et al. 2000. Molecular Cloning: A Laboratory Manual (III Edn.) CSHL Press
14. 13. Zhang, H-X., Zhang, Y., Yin, H. Genome Editing with mRNA encoding ZFN, TALEN, and Cas9. *Mol. Ther.* 27, 735-746 (2019).
15. 14. Khan, S.H., Genome-editing technologies: Concept, pros, and cons of various genome-editing techniques and bioethical concerns for clinical application. *Molecular Therapy- Nucleic Acids*, 16, 326-334 (2019).

Reference Books:

1. Kim, Y. G., Cha, J. & Chandrasegaran, S. Hybrid restriction enzymes: zinc finger fusions to Fok I cleavage domain. *Proc. Natl. Acad. Sci. U. S. A.* 93, 1156–1160 (1996).
2. Christian, M. *et al.* Targeting DNA double-strand breaks with TAL effector nucleases. *Genetics* 186, 757–761 (2010).

3. Cong, L. *et al.* Multiplex genome engineering using CRISPR/Cas systems. *Science* 339, 819–823 (2013).
4. Huang, X., Yang, D., Zhang, J., Xu, J., & Chen, Y. E.. Recent Advances in Improving Gene-Editing Specificity through CRISPR–Cas9 Nuclease Engineering. *Cells*, 11, 2186 (2022).
5. Cermak, T. *et al.* Efficient design and assembly of custom TALEN and other TAL effector-based constructs for DNA targeting. *Nucleic Acids Res.* 39, e82 (2011).
6. Szczepek, M. *et al.* Structure-based redesign of the dimerization interface reduces the toxicity of zinc-finger nucleases. *Nat. Biotechnol.* 25, 786–793 (2007).
7. Chen, J. S. *et al.* Enhanced proofreading governs CRISPR-Cas9 targeting accuracy. *Nature* 550, 407–410 (2017).
8. Kleinstiver, B. P. *et al.* High-fidelity CRISPR-Cas9 nucleases with no detectable genome-wide off-target effects. *Nature* 529, 490–495 (2016).
9. Slaymaker, I. M. *et al.* Rationally engineered Cas9 nucleases with improved specificity. *Science* 351, 84–88 (2016).
10. Murugan, K., Babu, K., Sundaresan, R., Rajan, R. & Sashital, D. G. The Revolution Continues: Newly Discovered Systems Expand the CRISPR-Cas Toolkit. *Mol. Cell* 68, 15–25 (2017).
11. Qi, L. S., Larson, M. H., Gilbert, L. A., Doudna, J. A., Weissman, J. S., Arkin, A. P., & Lim, W. A.. Repurposing CRISPR as an RNA-guided platform for sequence-specific control of gene expression. *Cell*, 152, 1173-1183 (2013).
12. Ribeiro, L. F., Ribeiro, L. F. C., Barreto, M. Q. & Ward, R. J. Protein Engineering Strategies to Expand CRISPR-Cas9 Applications. *Int. J. Genomics* 2018, 1652567 (2018).
13. Gilbert, L. A. *et al.* CRISPR-mediated modular RNA-guided regulation of transcription in eukaryotes. *Cell* 154, 442–451 (2013).
14. Konermann, S. *et al.* Genome-scale transcriptional activation by an engineered CRISPR-Cas9 complex. *Nature* 517, 583–588 (2015).
15. Liu, X. S. *et al.* Editing DNA Methylation in the Mammalian Genome. *Cell* 167, 233-247.e17 (2016).
16. Relevant research papers and articles

Web resources

1. www.agbios.com/main.php

2. www.cls.casa.colostate.edu/TransgenicCrops/what.html

3. www.mcb.uct.ac.za/manual/MolBiolManual.htm

4. www.web-books.com/MoBio/

Type of Course :	DSE Major / Elective course
Course Code:	BIOT/DSE/604-AP
Course Title :	**Plant Biotechnology II**
Teaching method:	**Practical**
Teaching Scheme :	(Hrs./ Week) 4
Credits Assigned :	2

Module No.	**Topics / actual contents of the syllabus**
I	Isolation of plant genomic DNA.
II	Demonstration of Agrobacterium mediated gene transfer
III	Transgenic analysis by Polymerase chain reaction
IV	Demonstration of Direct or vectorless gene transfer
V	Detection of transgene by Southern blotting
VI	Detection of plant protein by Western blotting
VII	RT-PCR
VIII	ELISA.

Type of Course	:	**DSE Major/ Elective**
Course Code	:	**BIOT/DSE/604-BT**
Course Title	:	**AI and System Biology**
Teaching method	:	**Classroom lectures**
Teaching Scheme	:	**02 Hrs./ Week**
Contact Hours	:	**30**
Credits Assigned	:	**2**

Learning Objectives of the Course:

8. Understand the fundamental concepts of systems biology and AI
9. Apply AI techniques to biological data
10. Develop computational models of biological systems
11. Analyse and interpret biological data using AI methods

Course Outcomes (COs) :

After completion of the course, students will be able to –

1. Understand and Explain Core Concepts of AI and System Biology
2. Analyse and Interpret Biological Data
3. Conduct Network Analysis & Integrate Multi-Omics Data
4. Use Advanced Bioinformatics Tools & Stay Updated with Emerging Trends

Module No	Topics / actual contents of the syllabus	Contact Hours
I	**Introduction to Systems Biology and AI**-Overview of systems biology, Introduction to artificial intelligence and machine learning, Historical perspective and key developments, **Biological Data and Databases**- Types of biological data (genomic, proteomic, metabolomic), Biological databases and data repositories, Data pre-processing and normalization, **Machine Learning Basics**-Supervised vs. unsupervised learning Key algorithms (e.g., decision trees, support vector machines, clustering), Evaluation metrics (accuracy, precision, recall, F1 score).	**10 Hrs**

II	**Deep Learning for Biological Data**-Introduction to neural networks and deep learning, Convolutional neural networks (CNNs) and recurrent neural networks (RNNs), Applications in genomics and proteomics, **Network Biology and Graph Theory**-Biological networks (gene regulatory networks, protein-protein interaction networks) Graph theory and network analysis, AI techniques for network inference and analysis.	**10 Hrs**
III	**Computational Modelling of Biological Systems-** Mathematical modelling and simulation of biological systems, Ordinary differential equations (ODEs) and stochastic models, AI-based approaches for model parameter estimation, **Omics Data Integration and Multi-omics Approaches**-Integration of multi-omics data (genomics, transcriptomics, proteomics, metabolomics), AI techniques for multi-omics data integration, Case studies and applications, **Special Topics and Emerging Trends-** Single-cell analysis and AI, AI in personalized medicine and drug discovery, Ethical considerations in AI and systems biology.	**10 Hrs**

Text Books:

- Barabási, A.-L. (2016). Network Science.
- Sharan, R., Ulitsky, I., & Shamir, R. (2007). Network-based prediction of protein function.
- Klipp, E., Herwig, R., Kowald, A., Wierling, C., & Lehrach, H. (2005). Systems Biology in Practice: Concepts, Implementation, and Application.
- Huang, S., Chaudhary, K., & Garmire, L. X. (2017). More is better: recent progress in multi-omics data integration methods.
- Maciejewski, M. L. (2020). Towards precision medicine: integrating artificial intelligence and systems biology.

Reference Books:

- Alon, U. (2007). An Introduction to Systems Biology: Design Principles of Biological Circuits.
- Russell, S., & Norvig, P. (2010). Artificial Intelligence: A Modern Approach.
- Kanehisa, M., & Goto, S. (2000). KEGG: Kyoto Encyclopedia of Genes and Genomes.
- Gentleman, R. (2008). Bioconductor: open software development for computational biology and bioinformatics.
- Bishop, C. M. (2006). Pattern Recognition and Machine Learning.
- Pedregosa, F. et al. (2011). Scikit-learn: Machine Learning in Python.
- Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning.
- LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning.

Scope: The scope of AI and systems biology is broad and continually expanding, driven by advances in technology and a growing understanding of complex biological systems.

Type of Course	:	**DSE Major/ Elective course**
Course Code	:	**BIOT/DSE/604-BP**
Course Title	:	**AI and System Biology**
Teaching method	:	**Practical**
Teaching Scheme	:	**(Hrs./ Week) 4**
Contact Hours	:	**60**
Credits Assigned	:	**2**

Learning Objectives of the Course:

1. Understand the fundamental concepts of systems biology and AI
2. Apply AI techniques to biological data
3. Develop computational models of biological systems
4. Analyse and interpret biological data using AI methods

Course Outcomes (COs) :

After completion of the course, students will be able to –

1. Understand and Explain Core Concepts of AI and System Biology
2. Analyse and Interpret Biological Data
3. Conduct Network Analysis & Integrate Multi-Omics Data
4. Use Advanced Bioinformatics Tools & Stay Updated with Emerging Trends

Module No	Topics / actual contents of the syllabus	Contact Hours
I II III	**Practical:** • Accessing and querying biological databases (e.g., NCBI, ENCODE) • Data preprocessing using Python/R • Implementing machine learning algorithms using scikit-learn • Model evaluation and validation	**60 Hrs**

	• Building and training neural networks using TensorFlow/Keras • Case study: Image-based analysis of biological data • Network analysis using NetworkX • Inferring gene regulatory networks • Modeling biological systems using MATLAB or COPASI • Case study: Modeling of metabolic pathways • Integrative analysis of multi-omics data • Machine learning approaches for integrative analysis	
	Suggested Tools and Software: • Programming Languages: Python, R • Libraries: scikit-learn, TensorFlow/Keras, NetworkX, pandas • Platforms: Jupyter Notebook, Google Colab • Software: MATLAB, COPASI, Cytoscape	

Text Books:

- Barabási, A.-L. (2016). Network Science.
- Sharan, R., Ulitsky, I., & Shamir, R. (2007). Network-based prediction of protein function.
- Klipp, E., Herwig, R., Kowald, A., Wierling, C., & Lehrach, H. (2005). Systems Biology in Practice: Concepts, Implementation, and Application.
- Huang, S., Chaudhary, K., & Garmire, L. X. (2017). More is better: recent progress in multi-omics data integration methods.
- Maciejewski, M. L. (2020). Towards precision medicine: integrating artificial intelligence and systems biology.

Reference Books:

- Alon, U. (2007). An Introduction to Systems Biology: Design Principles of Biological Circuits.
- Russell, S., & Norvig, P. (2010). Artificial Intelligence: A Modern Approach.
- Kanehisa, M., & Goto, S. (2000). KEGG: Kyoto Encyclopedia of Genes and Genomes.
- Gentleman, R. (2008). Bioconductor: open software development for computational biology and bioinformatics.
- Bishop, C. M. (2006). Pattern Recognition and Machine Learning.
- Pedregosa, F. et al. (2011). Scikit-learn: Machine Learning in Python.
- Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning.
- LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning.

Scope:

The scope of AI and systems biology is broad and continually expanding, driven by advances in technology and a growing understanding of complex biological systems.

Type of Course :	DSE Major / Elective course
Course Code:	BIOT/DSE/604-CT
Course Title :	**Advance techniques in Biotechnology**
Teaching method:	Classroom lectures
Teaching Scheme :	(Hrs./ Week) 2
Contact Hours:	30
Credits Assigned :	2

Learning Objectives of the Course:

1. Understand the fundamental concepts of Vaccines and antibody engineering.
2. 2. Understand the nanotechnology, nanomedicine and nanotoxicity.
3. 3. Understand the techniques of inherited disease diagnosis.
4. 4. Understand the basics of tissue engineering

Course Outcomes (COs) :

After completion of course students will be able to ..

1. Acquire knowledge and understanding of types of vaccines and their importance.
2. Apply knowledge for developing diagnostics kits.
3. Get acquainted with artificial intelligence and their use biotechnology research.

ModuleNo.	Topics / actual contents of the syllabus	Contact Hours
I	**Prevention and Treatment:** **A. Vaccine technology**: Introduction to Vaccines, Live, Killed, Attenuated, Subunit vaccines; Recombinant DNA and protein based vaccines, Peptide vaccines, Conjugate vaccines; Edible vaccine, Vaccines against Covid-19. **B. Antibody engineering:** Generation of monoclonal antibodies, hybrid monoclonal antibodies and catalytic antibody. Applications of antibody in diagnostic and therapy. **C. Nanomedicine**: Introduction to Nanotechnology and Nanomedicine. Lipid-based and Polymer-based nanoparticles for cancer therapy, Nanoparticles for theranostic applications, Nanotoxicity, Fate of nanomaterials in environment, Guidelines for Safe Handling of Nanomaterials in Research Laboratories and Industries.	**10 Hrs**
II	**Advance diagnostics:** **Advance diagnostics:** **A. Emerging clinical diagnostics:** Microarrays, FACS, Lab-on-a-Chip approach for molecular diagnosis, Introduction to SELDI-TOF and diagnostic proteomics. Nano-diagnostics. **B. Diagnosis of inherited diseases:** Fragile- X syndrome and Myotonic dystrophy. (both by Southern blotting),	**10 Hrs**

	Downs syndrome (qPCR), Cystic fibrosis (ARMS-PCR),	
III	**AI and Tissue technology:** **A. Artificial Intelligence:** Basics of AI, Applications of AI in biotechnology, Challenges and opportunities in integrating AI with biotechnological research. AI based disease detection tools/Apps, Ethical considerations in AI-driven biotechnological research, Regulatory challenges and guidelines. **B. Artificial tissue, artificial skeleton and IVF.** Three dimensional cell culture and tissue growth, 3D printing of tissue, cells and organs. Bio-artificial heart, Bio-artificial kidney. Basics and Rules & regulation of *In-vitro* fertilization (IVF).	**10 Hrs**

Text Books:

1. Roitt I M, Essential Immunology, Blackwell Scientoific Publicatuions,Oxford
2. Kuby – Immunology.
3. Ian Tizard (2005) Immunology: An Introduction. Cengage Learning (RS).
4. Anwarul Hasan (2017) Tissue Engineering for Artificial Organs: Regenerative Medicine, Smart Diagnostics and Personalized Medicine, Wiley Publication.
5. G.P. Talwar by A Handbook of Practical Immunology -

Reference Books:

1. Mahendra Rai and Indarchand Gupta (2024) Nanotoxicology for Agricultural a
2. nd Environmental Applications, Elsevier, USA.
3. Mahendra Rai, Mehdi Razzaghi-Abyaneh, Avinash P. Ingle (2020) Nanobiotechnology in Diagnosis, Drug Delivery and Treatment, Wiley, Edition.
4. Greg T. Hermanson (2013) Bioconjugate Techniques, 3rd Edition, Elsevier
5. J.T. George, Catherine E. Urch (2000) Diagnostic and Therapeutic Antibodies (Methods in Molecular Medicine), Humana Press.
6. Robert J. Brooker (2009) Genetics: Analysis and Principles, McGraw-Hill.

Online resource:

https://sites.google.com/view/irgclassroom/advance-techniques-in biotechnology?authuser=0

Scope:

The course will provide the in-depth insight about the recent and advance techniques in diagnosis and therapeutics including the help of AI, immunology and nanotechnology.

Type of Course :	DSC Major / Elective course
Course Code:	BIOT/DSE/604-CP
Course Title :	**Advance techniques in Biotechnology**
Teaching method:	practical
Teaching Scheme :	(Hrs./ Week)4
Contact Hours:	60
Credits Assigned :	2

ModuleNo.	Case studies of Autosomal / X-linked disorders
1.	Case studies of Autosomal / X-linked disorders
2.	PCR based detection of bacteria
3.	RT PCR based diagnosis of animal/human/plant disease (including qPCR)
4.	DNA/RNA based diagnosis HIV - CD 4 receptor.
5.	Online demonstration of AI tools.
6.	Synthesis of nanoparticles.
7.	Conjugation of nanoparticles with antibody.
8.	Detection of Dengue/ Malaria (by ELISA or RAPID kits).
9.	Detection of Chikungunya (by ELISA or RAPID kits).
10.	Detection of Covid-19/ TB (by ELISA or RAPID kits).
11.	Detection of antigen by Enzyme Linked Immunosorbent Assay/ Western blotting.
12.	To perform Microtomy techniques (Animal Tissue).
13.	Preparation of tissue culture media.
14.	Trypsinization/ Preparation of cell suspension from organ

Text Books:

1. Roitt I M, Essential Immunology, Blackwell Scientoific Publicatuions,Oxford
2. Kuby – Immunology.
3. Ian Tizard (2005) Immunology: An Introduction. Cengage Learning (RS).
4. Anwarul Hasan (2017) Tissue Engineering for Artificial Organs: Regenerative Medicine, Smart Diagnostics and Personalized Medicine, Wiley Publication.
5. G.P. Talwar by A Handbook of Practical Immunology -

Reference Books:

1. Mahendra Rai and Indarchand Gupta (2024) Nanotoxicology for Agricultural a
2. nd Environmental Applications, Elsevier, USA.
3. Mahendra Rai, Mehdi Razzaghi-Abyaneh, Avinash P. Ingle (2020) Nanobiotechnology in Diagnosis, Drug Delivery and Treatment, Wiley. Edition.
4. Greg T. Hermanson (2013) Bioconjugate Techniques, 3rd Edition, Elsevier
5. J.T. George, Catherine E. Urch (2000) Diagnostic and Therapeutic Antibodies (Methods in Molecular Medicine), Humana Press.
6. Robert J. Brooker (2009) Genetics: Analysis and Principles, McGraw-Hill.

Online resource:

https://sites.google.com/view/irgclassroom/advance-techniques-in biotechnology?authuser=0

Scope:

The course will provide the in-depth insight about the recent and advance techniques in diagnosis and therapeutics including the help of AI, immunology and nanotechnology.

Type of Course:	DSE Major/ Elective Course
Course Code:	BIOT/DSE/604-DT
Course Title:	**Entrepreneurship in Biotechnology**
Teaching method:	Classroom lectures
Teaching Scheme:	(Hrs./ Week) 2
Contact Hours:	30
Credits Assigned:	2

Course Description:

This course is designed to provide an in-depth understanding of the principles and practices of entrepreneurship within the biotechnology sector, with a particular focus on both global and Indian contexts. Students will explore the dynamics of the biotech industry, gain insights into business planning and strategy, and develop skills in financial management and funding acquisition. The course will also cover regulatory considerations, intellectual property management, and market analysis, providing a comprehensive framework for launching and managing successful biotech ventures.

Learning Objectives of the Course:

1. To provide a comprehensive overview of the biotechnology industry, highlighting current trends, key sectors, and future prospects with a focus on both global and Indian markets.
2. To equip students with the necessary skills to generate and validate business ideas, develop robust business plans, conduct market research, and understand regulatory and intellectual property considerations.
3. To impart knowledge on financial planning and management, explore various funding sources, and teach students how to effectively pitch to investors and manage risks in the biotech industry.

Course Outcomes (COs):

After completion of the course, students will be able to -

1. Students will gain a deep understanding of the biotechnology industry, including its global and Indian landscapes, enabling them to identify opportunities and challenges within the sector.
2. Students will be able to develop detailed business plans, conduct thorough market research, and navigate regulatory and IP management complexities, preparing them to launch and manage biotech ventures.
3. Students will acquire skills in financial planning and management, learn to secure funding from various sources, and effectively pitch to investors, ensuring the financial viability of their biotech ventures.

Module No.	Topics / actual contents of the syllabus	Contact Hours
I	**Unit I: Introduction to Entrepreneurship in Biotechnology (0.5 Credits)** ***Definition and Scope:*** Understanding entrepreneurship and its relevance in biotechnology. Differences between entrepreneurs, intrapreneurs, and managers.	7.5 Hrs

	Biotechnology Industry Overview: Current trends and prospects in the global and Indian biotech industries. Key sectors within biotechnology: pharmaceuticals, agriculture, environmental biotechnology, industrial biotech, etc. ***Types of Biotech Ventures:*** Start-ups, spin-offs, and established companies. Public vs. private sector enterprises. Characteristics of Successful Biotech Entrepreneurs: Global and Indian case studies of successful biotech entrepreneurs. Skills and qualities required for success in the biotech industry ***Case Studies:*** **Biocon India** **Overview:** Explore the journey of Biocon, India's leading biopharmaceutical company, from its inception to becoming a global player. **Focus:** Examine the entrepreneurial strategies of founder Kiran Mazumdar-Shaw, challenges faced, and the company's growth in the Indian and global markets. **Reference:** "Biocon India Group: A Pioneer in the Biopharmaceutical Industry" - Harvard Business School Case Study. **2. Genentech** **Overview:** Investigate the founding and growth of Genentech, one of the first biotechnology companies. **Focus:** Understand the role of innovation and venture capital in the company's early years, and its impact on the biotech industry. **Reference:** "Genentech: After the Acquisition by Roche" - Harvard Business School Case Study.	
II	**Unit II: Business Planning and Strategy (0.75 Credits)** ***Business Idea Generation and Validation:*** Identifying market needs and opportunities. Techniques for idea generation and validation. Contextualizing to the global and Indian markets. ***Business Plan Development:*** Components of a business plan: executive summary, company description, market analysis, organizational structure, product line, marketing and sales strategies, funding request, financial projections. Importance of a solid business plan in securing funding. Case studies of successful business plans from global and Indian biotech firms. ***Market Research and Competitive Analysis:*** Conducting market research to understand customer needs and market dynamics. Analyzing competitors and identifying	11.25 Hrs

	competitive advantages. Specific examples from global and Indian contexts. ***Regulatory Considerations:*** Overview of global and Indian regulatory requirements in biotechnology. Comparison of regulatory frameworks in different regions. ***Intellectual Property (IP) Management:*** Importance of IP in biotechnology. Types of IP and strategies for protecting intellectual property. Differences in IP laws and practices between India and other countries. ***Case Studies:*** **Ginkgo Bioworks** **Overview:** Study the business model and strategy of Ginkgo Bioworks, a company specializing in custom microorganisms for industrial applications. **Focus:** Analyze their business plan development, market research, and competitive analysis. **Reference:** "Ginkgo Bioworks: Organism Company" - Harvard Business School Case Study. **Bharat Biotech** **Overview:** Examine Bharat Biotech's approach to vaccine development, particularly the launch of the COVID-19 vaccine, Covaxin. **Focus:** Discuss regulatory challenges, business planning, and the strategies employed to bring the vaccine to market in India. **Reference:** "Bharat Biotech: Innovating at the Frontier" - Indian School of Business Case Study.	
III	**Unit III: Funding and Financial Management (0.75 Credits)** ***Sources of Funding:*** Overview of different funding sources: venture capital, angel investors, government grants, crowdfunding, and strategic partnerships. Advantages and disadvantages of each funding source. Funding landscape in the global and Indian biotech sectors. ***Financial Planning and Management:*** Basic financial statements: balance sheet, income statement, cash flow statement. Financial planning, budgeting, and forecasting. Examples from global and Indian biotech companies. ***Valuation of Biotech Ventures:*** Methods for valuing biotech companies. Factors influencing valuation. Specific considerations in the Indian market.	11.25 Hrs

	Pitching to Investors: Crafting a compelling pitch. Presenting to potential investors: do's and don'ts. Successful pitch examples from global and Indian biotech startups. ***Risk Management:*** Identifying and mitigating risks in biotech ventures. Contingency planning and crisis management. Case studies highlighting risk management in global and Indian contexts. ***Case Studies:*** **Moderna** **Overview:** Analyze the financial strategies of Moderna, focusing on its funding journey and financial management leading to the development of the COVID-19 vaccine. **Focus:** Review their fundraising strategies, investor pitches, and financial planning. **Reference:** "Moderna: Beyond COVID-19" - Harvard Business School Case Study. **Study: Dr. Reddy's Laboratories** **Overview:** Explore how Dr. Reddy's Laboratories secured funding and managed finances to expand its operations and enter new markets. **Focus:** Understand the challenges and strategies in financial planning and risk management in the Indian context. **Reference:** "Dr. Reddy's Laboratories: Realizing a Vision" - Harvard Business School Case Study.	

Text Books:

Reference Books:

1. Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies" by Craig Shimasaki.
2. The Entrepreneur's Guide to a Biotech Startup" by Peter Kolchinsky.
3. Commercializing Biotech Products" by Shreefal Mehta.
4. Biotechnology in India: Innovation and Entrepreneurship" by K.K. Tripathi.

Review Articles:

3. Tearing up the traditional biotech playbook. Nat Biotechnol 42, 1 (2024). https://doi.org/10.1038/s41587-023-02119-6
4. MODERN BIOTECHNOLOGY AND INDIA'S GOVERNANCE IMPERATIVES Ananth Padmanabhan, R. Shashank Reddy, and Shruti Sharma, this publication can be downloaded at no cost at CarnegieIndia.org

Scope:

The course encompasses comprehensive industry knowledge, business planning and strategy development as well as financial acumen and investor relations.

Type of Course:	DSE Major/ Elective Course
Course Code:	BIOT/DSE/604-DP
Course Title:	**Entrepreneurship in Biotechnolog**
Teaching method:	Practical
Teaching Scheme:	(Hrs./ Week) 4
Contact Hours:	60
Credits Assigned:	2

Course Description:

This lab course is designed to provide hands-on experience in entrepreneurship within the biotechnology sector. Students will engage in practical exercises that simulate real-world scenarios, including market research, business planning, financial management, and pitching to investors. The course will also emphasize regulatory considerations and strategic planning.

Learning Objectives of the Course:

1. To develop practical skills in creating and evaluating business plans for biotechnology ventures.
2. To understand and apply financial management principles in biotechnology startups.
3. To gain experience in pitching business ideas to potential investors and stakeholders.

Course Outcomes (COs):

After completion of the course, students will be able to -

1. Conduct comprehensive market research and competitive analysis for biotechnology products.
2. Develop detailed business plans and financial projections for biotechnology startups.
3. Effectively present and pitch business ideas to investors and stakeholders.

Module No.	Topics / actual contents of the syllabus	Contact Hours
I	**Unit I: Unit I: Market Research and Business Planning** **1. Market Research Techniques** **Lab Activity:** Develop a market research survey and analyze the results. By conducting surveys and interviews, analyzing market trends and identifying target markets. **2. Competitive Analysis** **Lab Activity:** Perform a SWOT analysis for a selected biotechnology company. By Identifying competitors and performing the SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) **3. Business Plan Development** **Lab Activity:** Draft a business plan for a hypothetical biotechnology startup. By preparing an executive summary, product or service description,	20 Hrs

	market analysis, marketing, and sales strategies	
II	**Unit II: Financial Management and Funding** 1. **Financial Projections and Budgeting** **Lab Activity:** Create financial projections and budgets for a biotechnology business plan. By creating Income statements, doing cash flow analysis and break-even analysis 2. **Funding Strategies** **Lab Activity:** Prepare a funding proposal for a biotechnology startup. Using various types of funding (venture capital, angel investors, grants, etc.) and preparing funding proposals 3. **Financial Risk Management** **Lab Activity:** Analyze financial risks and develop mitigation strategies for a biotechnology venture. By identifying financial risks and using risk mitigation strategies.	20 Hrs
III	**Unit III: Pitching and Regulatory Considerations** 1. **Pitching to Investors** **Lab Activity:** Develop and deliver a pitch deck to a mock panel of investors. By crafting an elevator pitch, preparing pitch decks and using effective communication skills 2. **Regulatory Considerations** **Lab Activity:** Research and present regulatory requirements for a specific biotechnology product in different markets. By using an overview of biotechnology regulations (global and Indian perspectives) and compliance and regulatory strategies 3. **Strategic Planning and Execution** **Lab Activity:** Create a strategic plan for a biotechnology startup and outline key performance indicators (KPIs). By setting business goals and objectives, developing strategic initiatives and monitoring & evaluating business performance	20 Hrs
Text Books:		
Reference Books: 1. "Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies" by Craig Shimasaki 2. "Biotechnology Entrepreneurship: From Science to Solutions" by Damian Hine and John Kapeleris 3. "The Lean Startup: How Today's Entrepreneurs Use Continuous		

Innovation to Create Radically Successful Businesses" by Eric Ries.

Articles & Case Studies:

1. "Biocon India Group: A Pioneer in the Biopharmaceutical Industry" - Harvard Business School Case Study
2. "Genentech: After the Acquisition by Roche" - Harvard Business School Case Study
3. "Ginkgo Bioworks: Organism Company" - Harvard Business School Case Study
4. "Bharat Biotech: Innovating at the Frontier" - Indian School of Business Case Study
5. "Moderna: Beyond COVID-19" - Harvard Business School Case Study
6. "Dr. Reddy's Laboratories: Realizing a Vision" - Harvard Business School Case Study

Online Resources:

- Coursera: Biotechnology Entrepreneurship Specialization
- MIT OpenCourseWare: New Enterprises

Scope:

This practical lab course will equip students with the skills and knowledge necessary to navigate the entrepreneurial landscape of the biotechnology industry, focusing on real-world applications and problem-solving.

Type of Course :	**DSE Major / Elective course**
Course Code:	BIOT/DSE/604-E
Course Title :	**An Online certification course from NPTEL /SWAYM /MOOC of equivalent credits { with biology basis }**
Teaching method:	**Online Teaching**
Credits Assigned :	**4**

In case a student opts online course as, **BIOT/DSE/604-E** the curriculum, rules, regulations, and scheme of assessment etc of the course conducting agency will be binding of the student. The student should submit the course completion certificate to the department and deposit his/her earned credits in ABC.

Type of Course :	**mandatory course**
Course Code:	**BIOT/ RP /605**
Course Title :	**Research Project Stage I**
Teaching method:	**Research work**
Credits Assigned :	4

Course Description:

This lab course is designed to provide hands-on experience on specific research area in Biotechnology. It aims to develop students' ability to conduct independent research, enhance their skill sets to contribute to the updated knowledge in biotechnology. This will allow the students to apply this knowledge and skills to a specific research in the field of biotechnology.

Learning Objectives of the Course:

1. To learn literature reviews to frame research work and topic within allied area of Biotechnology.
2. To design and plan experiments to effectively address research topic.
3. To aquire skill sets for necessary microbial/ biochemical techniques and to handle required instruments.
4. To utilize appropriate statistical and computational tools to analyze research data accurately
5. To develop practical skills in creating and evaluating any experimental data

Course Outcomes (COs):

After completion of the course, students will be able to -

1. do the literature survey of any decided topic of research and will be able to frame the research work and topic.
2. design and plan experiments or studies to effectively address research topic.
3. Develop skill sets for necessary microbiall techniques and to handle required instrument.

Scope:

Students will select a research topic related to biotechnology, which may encompass areas such as genetic engineering, molecular biology, bioinformatics, bioprocess engineering, environmental biotechnology, medical biotechnology, or agricultural biotechnology.

General guide lines:

1. This is the 4 credit course where student will start their dissertation work on relevant topic.
2. At the start of semester students need to prepare the synopsis of their research project for IIIrd ans IV the semester.

3. Periodically the students have to discus their progress updates with their project guide.
4. At the end of semester, students would submit and present their progress and updates of dissertation as, 'Title Defence' .
5. Evaluation will be done on the basis of students's work done by the student , presentation and report submission.

Semester IV

Illustrative Credit distribution structure for Two Years/One Year Programme with Multiple Entry and Exit options –
(Discipline Specific Core in Biotechnology)
Class: M.Sc. Second Year (Semester: IVth) Subject: Biotechnology

EXPLAINATION OF CODE:

Course type	Course Code	Course Name	Teaching Scheme (Hrs./ week)		Credits Assigned Training Hrs/week		Total credits
			Theory	Practical	Theory	Practical	
Major Mandatory DSC	BIOT/MJ/650-T	Industrial Technology	2	-	2	-	4+4+4= 12
	BIOT/MJ/650-P	Lab Course Based On BIOT/MJ/650- T	-	4	-	2	
	BIOT/MJ/651-T	rDNA technology	2	-	2	-	
	BIOT/MJ/651-P	Lab Course Based On BIOT/MJ/651- T	-	4	-	2	
	BIOT/MJ/652-T	Bioinformatics	2	-	2	-	
	BIOT/MJ/652-P	Lab Course Based On BIOT/MJ/652- T	-	2	-	2	
DSE (Choose any one from pool of courses)	BIOT/DE/653-AT	**Environmental Biotechnology**	2	4	2	2	4
	BIOT/DE/653-AP	Lab Course Based On Environmental Biotechnology					
	BIOT/DSE/653-BT	**Animal Biotechnology-II**					
	BIOT/DSE/653-BP	Lab Course Based Animal Biotechnology-II					
	BIOT/DSE/653-CT	**Synthetic Biology**					
	BIOT/DSE/653-CP	Lab Course Based Synthetic Biology					
	BIOT/DSE/653-DT	**Pharmaceutical Biotechnology**					
	BIOT/DSE/653-DP	Lab Course Based Pharmaceutical Biotechnology					
	BIOT/DSE/653-E	**(MOOC Course) Or any Online certification course from NPTEL /SWAYM /MOOC of equivalent credits { with biology basis }**					
RP	BIOT/ RP /654	**Research Project Stage II**	-	12	-	6	6
			13	18	10	9	**22 credits**

BIOT=BIOTECHNOLOGY, MJ=Discipline specific core, Major/Mandatory; RM= RESEARCH project ; T= THEORY, P= PRACTICATS , 650-655- COURSE CODE AS PER GUTDELTNES of NEP- 2020

Type of Course:	DSC Major / Mandatory Major course
Course Code:	BIOT/MJ/650-T
Course Title:	**Industrial Biotechnology**
Teaching method:	Classroom lectures
Teaching Scheme:	(Hrs./ Week) 2
Contact Hours:	30
Credits Assigned:	2

Learning Objectives of the Course:

- To provide fundamental insights into wide spectrum of Industrial biotechnology.
- To gain knowledge about microbes as a resource for products of huge industrial significance.
- To develop knowledge and generate curiosity in understanding different fermentation strategies.
- To understand the environmental and economical sustainability associated with industrial biotechnology.

Course Outcomes (CO):

- Ability to comprehend the established industrial biotechnological products in health, agriculture, and environmental spectrum.
- Ability to demonstrate the fundamental understanding about microbes as a potential source of lucrative products.
- Ability to connect a sense of perspective towards efficient environmentally sustainable viable options.
- Ability to understand and strategize production methods based upon the knowledge gained through practical and laboratory exposure.

ModuleNo.	Topics / actual contents of the syllabus	Contact Hours
I	**Microbial Products for Human Health and Consumption** **Antibiotics:** Discovery and Development, industrially important antibiotic producing microbes, antibiotic fermentation process (Penicillin, Streptomycin, Tetracycline) **Recombinant products:** Chymosin production, Recombinant and synthetic vaccines (Overview and limitations of traditional vaccines), Vitamins (B12 and riboflavin A). Bacterial pigments and its therapeutic applications **Microbes in food industry**: Fermented foods (breads, sauerkraut, soy-sauce and tofu) Dairy products from microbes (cheese, curd, yoghurt), microbes as food - single cell protein, mushrooms, probiotics. **Alcoholic beverages:** Brief history of development of	**10 Hrs**

	industrial process, production of wine – raw materials used, fermentation, clarification and aging. **Organic acids and Solvents**: Citric acid and ABE production.	
II	**Microbial Products for Agriculture and Industrial Enzymology** **Agriculture:** Biofertilizers – History of biofertilizers and the importance of biofertilizers, description and characteristics of biofertilizers-Rhizobium, Azotobacter, Azospirillum, Blue Green Algae, Azolla, Phosphate solubilizing microorganisms, VAM) and Vermicomposting. Biopesticides – history of development, production of biopesticides from bacteria, fungi and viruses and their applications against different types of pathogens, background note on Bt Cotton (Development and its impact in current scenario). **Enzyme in Industry:** Important industrial enzymes and its application, Amylase and Lipase production - selection of organism, formulation of medium, production process, recovery and purification, Papain –Sources, Uses, Extraction, purification and characterization, Introduction to Nanozymes-Definition, Properties and Application.	**10 Hrs**
III	**Environmental Roles of Microorganisms** **Biohydrogen Production:** Microbial electrolysis system, basic fundamentals, dark fermentation for biohydrogen production, biohydrogen production using algal biomass and organic rich wastewater systems (importance, challenges and future opportunities). **Electricigens and Microbial Fuel Cell**: Definition, Common types of electricigens, electron transfer mechanism (*Shewenella and Geobacter*), application in bioenergy production. **Biosurfactants:** Definition, classification, types and their application in environment, petroleum recovery and other fields, U.S Patent with reference to Ananda Chakraborty (Oil eating bacteria-Superbug) **Bioplastics:** Definition, Properties, Microbial Origin, PHA/B production, extraction and recovery, applications of PHA/B biopolymer. **Bioleaching:** History, organisms used, mechanism of metal leaching and applications	**10 Hrs**

Reference Books:

1. Principles of Fermentation Technology – Stanbury, P.F. and Whitaker, A. Pergamon Press. Oxford

2. Manual of Industrial Microbiology and Biotechnology, III[rd] Edition – Demain, A. L. and Davies J. ASM Press
3. Food Microbiology – Frazier W.C. McGraw-Hill Ed.
4. Industrial Microbiology- Casida, L.E. John Wiley and Sons
5. Biotechnology: A textbook of Industrial Microbiology-Cruger, W. and Criger A.
6. Biopesticides Handbook (2019) – Nollet, Rathore and Singh, CRC Press.
7. Manufacture of Biofertilizer and Organic Farming – Panda, H.
8. Enzyme Technology- Chaplin, Martin F., Bucke, Cristopher
9. Handbook of Enzyme Biotechnology – Wiseman III Edition, Ellis Harwood
10. Environmental Biotechnology: Principle and Applications – Rittmann, B. E. and Mccarty P.L, McGraw Hill Publishing Company Ltd, 2001
11. Wastewater Engineering: Treatment Disposal and Reuse- Mecalf and Eddy, McGrawHill Publishing Company Ltd, 1991
12. Biosensors – Joshi Rajmaohan, I[st] Edition, Gyan Books, 2006
13. Biosensors – Cooper J.M. and Anthony E.G, IIrd Edition, Oxford University Press, 2004.
14. Organic Mushroom Farming and Mycoremediation: Cotter. T. (2004), Chelsea Green Publishing.
15. Industrial Waste Treatment-Rao and Dutta, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Scope: *The learning content designed is aimed to acquaint students with the core areas of Industrial Biotechnology. It measures a span of understanding about application of gained knowledge based upon human health, agriculture, and environmental sciences.*

Type of Course:	DSC Major / Mandatory Major course
Course Code:	BIOT/MJ/650-P
Course Title:	Industrial Biotechnology
Teaching method:	Laboratory based Practical
Teaching Scheme:	(Hrs./ Week)4
Contact Hours:	60
Credits Assigned:	2

Learning Objectives of the Course:

- To develop practical approach in designing a production methodology
- To foster the experimental skills needed to understand the optimization of development production process.
- To impart skills in interpreting the outcome of various strategies/ parameter on product yield

Course Outcomes (CO):

- Capable to design a protocol based upon different possible biological sources
- Ability to demonstrate the experimental skill needed for optimization studies.
- Ability to analyse and interpret the results and modify necessary parameter to improve product yield.

Module No.	**Practical**	Contact Hours
I	1. Production of Penicillin by fermentation 2. Microbial pigment production 3. Wine production using suitable substrates and its downstream processing 4. Production of Citric Acid using bacterial/fungal species. 5. Production of bioinsecticides/biofertilizers (Isolation, production, Purification and Assay) 6. Microbial enzyme production and its characterization – Amylase/ Protease/Lipase 7. Isolation and screening of microbes for biosurfactant production. 8. Production of PHA/PHB using microbial sources 9. Bioleaching of metals from ores/e-waste using *A. ferrooxidans/A. thiooxidans* 10. Visit to ETP/ clean room of Pharma Industry/ Mushroom Farm.	**10 Hrs**

References:

1. Principles of Fermentation Technology, Stanbury, P.F. and Whitaker, A. Pergamon Press, Oxford.
2. Manual of Industrial Microbiology and Biotechnology, III edition (1999), Arnold L. Demain and Julian Davies, ASM press, Washington DC

3. Nollet, Leo M. L. (Editor), Rathore, Hamir Singh (Editor) (2019) Biopesticides Handbook. CRC Press
4. H. Panda. Manufacture of Biofertilizer and Organic Farming.
5. Asenjo and Juan A. Asenjo, Separation Processes in Biotechnology, CRC Press, 1990.

Scope: The practical module is designed to enable the students to translate theoretical knowledge into experimental skill. The miniature understanding about the laboratory scale productions will let them have an imaginative delve into large Industrial scale productions.

Type of Course :	DSC Major / Mandatory Major course
Course Code:	BIOT/MJ/651-T
Course Title :	**Recombinant DNA Technology**
Teaching method:	Classroom lectures
Teaching Scheme :	(Hrs./ Week) 2
Contact Hours:	30
Credits Assigned:	2

Course Description:

This course provides an in-depth understanding of principles, methods and applications in recombinant DNA technology, genome mapping tools, gene silencing mechanisms, gene cloning, and throws light on various emerging molecular tools used for genetic alteration and recombinant product preparation .

Learning Objectives of the Course:

1. To introduce the foundational concepts and methodologies in cloning
2. To explore the tools and technologies used in designing and constructing recombinant products.
3. To make the student familiar with the currently used techniques to manipulate/ analyse DNA, RNA and proteins.

Course Outcomes (COs):

After completion of the course, students will be able to -

1. Understand the principle and the concept of cloning strategies, applications of PCR and know how to make and screen nucleic acid libraries.
2. Utilize various tools and technologies for designing and constructing recombinant products.
3. Explores the applications of RDT and highlighting emerging areas in the this field.

ModuleNo.	Topics / actual contents of the syllabus	Contact Hours
I	**Unit I: Introduction to RDT (1 Credit)** ***Introduction of RDT:*** Scope and significance of rDNA Technology ***Key Concepts and Methodologies:*** Introduction to cloning, preparation and screening of genomic DNA and cDNA library, Full length cDNA Oligocapture method and Oligo capping method, Hybridization techniques: northern, southern, south-western, colony hybridization, plaque lift assay, Chromosome walk, Immunological Screening. ***Genome mapping tools:*** RFLP, AFLP, EST, SSR, SNP, *GISH, FISH* ***Gene silencing technologies*** Introduction to siRNA; siRNA technology; Micro RNA; construction of siRNA vectors; principle and application of gene knockouts and gene therapy, Antisense technology	**14 Hrs**
II	**Unit II: Tools and Technologies in rDNA Technology (0.5 Credit)** ***PCR Techniques:*** Principle and applications of PCR, Primer designing, Types of PCR: Real –Time PCR, nested PCR, inverse PCR, multiplex PCR, touchdown PCR, hot start PCR, colony PCR, asymmetric PCR, LMPCR	**8 Hrs**

	DNA sequencing: Maxum and Gilbert, Sangers, NGS: overview of various platforms, illumina platform. ***Site Directed Mutagenesis:*** double primer method, cassette mutagenesis, error prone PCR ***DNA Microarray:*** construction of genomic arrays, cDNA arrays and oligo arrays;	
III	**Unit III: Applications and Emerging trends (0.5 Credit)** ***Applications of rDNA Technology:*** Transgenic plants and animals, Bt Cotton, Genetic engineering of plants for viruses, herbicide tolerance, GMO, debate over GM crops, metabolic engineering, Protein engineering: - AAT, Subtilisin, streptokinase, **Emerging Trends and Technologies:** Introduction to genome editing by CRISPR-CAS, TALENs and ZFN, m-RNA based therapeutics: mRNA vaccine, Introduction of CART therapy and preparation of expression construct, overview, construction and applications of recombinant antibodies(rAbs-scFc, Fabs), biphasic antibody,	**8 Hrs**

Text Books:

Reference Books:

1. " Old, R. W., Primrose, S. B., & Twyman, R. M. (2001). Principles of Gene Manipulation: an Introduction to Genetic Engineering. Oxford: Blackwell Scientific Publications.
2. Green, M. R., & Sambrook, J. (2012). Molecular Cloning: a Laboratory Manual. Cold Spring Harbor, NY: Cold Spring Harbor Laboratory Pres
3. " Nicholl, Desmond S. T. An Introduction To Genetic Engineering 4 Revised edition, Published by Cambridge University Press, 2023.
4. Brown, T. A. (2023). Genomes (5 ed.). CRC press, Boca Raton
5. " Bernard R. Glick, Jack J. Pasternak, and Cheryl L. Patten. (2003) Molecular Biotechnology: principles and applications of recombinant DNA.
6. Recombinant DNA by J.D.Watson, (2003) W.H. Freeman publisher, New York.
7. Robertson D, Scott S, Miller D, 1997, Manipulation and expression of recombinant DNA: Lab Manual, Academic press.
8. Jennifer A. Doudna and Samuel H. Sternberg, 2018. A Crack In Creation: Gene Editing and the Unthinkable Power to Control Evolution, Random House London.

Review Articles:

1. Martin Pacesa, Oana Pelea, Martin Jinek, 2024.Past, present, and future of CRISPR genome editing technologies,Cell,187(5): 1076-1100, https://doi.org/10.1016/j.cell.2024.01.042.
2. ""Xu Y, Li Z. CRISPR-Cas systems: Overview, innovations and applications in human disease research and gene therapy. Comput Struct Biotechnol J. 2020 Sep 8:18:2401-2415. doi: 10.1016/j.csbj.2020.08.031
3. Wada, N., Ueta, R., Osakabe, Y. et al. Precision genome editing in plants:

state-of-the-art in CRISPR/Cas9-based genome engineering. BMC Plant Biol 20, 234 (2020). https://doi.org/10.1186/s12870-020-02385-5
4. "Gray, A., Bradbury, A.R.M., Knappik, A. et al. Animal-free alternatives and the antibody iceberg. Nat Biotechnol 38, 1234–1239 (2020). https://doi.org/10.1038/s41587-020-0687-9 .
5. " Basu, K., Green, E. M., Cheng, Y., & Craik, C. S. (2019). Why recombinant antibodies — benefits and applications. Current Opinion in Biotechnology, 60, 153–158. doi:10.1016/j.copbio.2019.01.012
6. " Unkauf T, Miethe S, Fühner V, Schirrmann T, Frenzel A, Hust M. Generation of Recombinant Antibodies Against Toxins and Viruses by Phage Display for Diagnostics and Therapy. Adv Exp Med Biol. 2016;917:55-76. doi: 10.1007/978-3-319-32805-8_4.
7. " Jogalekar MP, Rajendran RL, Khan F, Dmello C, Gangadaran P, Ahn BC. CAR T-Cell-Based gene therapy for cancers: new perspectives, challenges, and clinical developments. Front Immunol. 2022 Jul 22;13:925985. doi: 10.3389/fimmu.2022.925985.
8. Lam JK, Chow MY, Zhang Y, Leung SW. siRNA Versus miRNA as Therapeutics for Gene Silencing. Mol Ther Nucleic Acids. 2015 Sep 15;4(9):e252.
9. Carthew RW, Sontheimer EJ. Origins and Mechanisms of miRNAs and siRNAs. Cell. 2009 Feb 20;136(4):642-55.

Online Resources :

1. https://www.sinobiological.com/resource/antibody-technical/recombinant-antibody-overview
2. https://www.antibodies.com/primary-antibodies/recombinant-antibodies
3. BioGRID http://thebiogrid.org/
4. Nebcutter https://nc3.neb.com/NEBcutter/

Scope:

This course provides a comprehensive overview of recombinant DNA technology, emphasizing both theoretical knowledge and practical applications, preparing students for research and careers in this rapidly evolving field.

Type of Course :	DSC Major / Mandatory Major course
Course Code:	**Recombinant DNA Technology**
Course Title :	BIOT/MJ/651-P
Teaching method:	practical
Teaching Scheme :	(Hrs./ Week)4
Contact Hours:	60
Credits Assigned :	2

Course Outcomes(COs)

After completion of the course students will able to

1. Design the in-silico PCR primer and perform e-PCR.
2. Develop the gene amplification protocol
3. Develop the gene editing skills
4. Design an experiment for the expression of genes.
5. Gain hands on training on Blotting techniques

ModuleNo.	Topics / actual contents of the syllabus
1.	Isolation of total genomic DNA of bacteria and determination of its purity.
2.	Isolation of Nuclei –yeast
3.	Isolation and purification of yeast mRNA
4.	In-silico primer designing and e-PCR
5.	Polymerase Chain Reaction and analysis by agarose gel electrophoresis
6.	Gene editing using Crisper cas system
7.	Restriction digestion, separation and transfer of Eukaryotic genomic DNA –Southern Blotting
8.	Northern Blotting
9.	Western Blotting
10.	Cloning of a trait and selection of the same in *E. coli*.
11.	Studying expression of recombinant protein (qualitative and quantitative) in *E. coli*.
12.	Problem based on restriction mapping

Selected Readings:

1. Sambrook, I., Fritsch, E.F. and Maniatis, T. (2001). Molecular Cloning 1, 2, 3 - A Laboratory Manual (3rd ed). USA: Cold Spring Laboratory Press.
2. Brown, T.A. (1998). Molecular Biology Lab Fax 11 Gene Analysis. London: Academic Press.
3. Berger, S.L. and Kimmel, R. (1987). Guide to Molecular Cloning Techniques. New York: Academic Press, Inc.
4. Verma, A.S., Surajit, D and Anchal, S. (2014). Laboratory Manual for Biotechnology. New Delhi: S. Chand and Company Ltd.
5. PCR Cloning Protocols edited by Bing-Yuan Chen and Harry W. Janes, Second Edition,2002. Humana Press.

Type of Course :	DSC Major / Mandatory Major course
Course Code:	BIOT/MJ/652-T
Course Title :	**Bioinformatics**
Teaching method:	Classroom lectures
Teaching Scheme :	(Hrs./ Week) 2
Contact Hours:	30
Credits Assigned :	2

Learning Objectives of the Course:
After successful completion of this course student will learn about,

1. Biological Databases
2. Genomics and Sequence Analysis
3. About proteoics

Course Outcomes (COs) :
After completion of the course, students will be able to understand -

1. Protein sequencing Databases
2. Genomics and Sequence Analysis
3. About proteomics

Module No.	Topics / actual contents of the syllabus	Contact Hours
I	**Unit 1-Introduction to Bioinformatics and Biological Databases** Introduction to Bioinformatics, History of Bioinformatics, Scope and applications of Bioinformatics, Nature of biological data, Introduction to biological databases, Primary Nucleic acid sequence database- GenBank, EMBL, DDBJ. Protein sequence database; Primary protein sequence databases; Swiss_Prot, PIR, MIPS, TrEMBEL, Secondary Protein Sequence Databases: PROSITE, PROFILE, BLOCKS, PRINTS, Pfam, IDENTIFY. Specialized database;-OMIM, Structural databases; PDB. Metabolic Pathway databases-KEGG, BRaunschweig ENzyme Database (BRENDA), Human Genome Project, Genomes OnLine Database (GOLD).	**10 Hrs**
II	**Unit 2- Genomics and Sequence Analysis** Genome sequencing strategies, Overview of concepts in sequence analysis, pairwise and multiple sequence alignment and significance, Local and global sequence alignment and its algorithm, Needleman-Wunsch, Smith-Waterman algorithm, Sequence similarity search tools-BLAST and FASTA - Concept, algorithm and working procedure, Multiple sequence alignment, ClustalW, Phylogenetic tree - construction methods, Phylogenetic analysis, Tree Evaluation method-Bootstrap. Genome information and special features, coding sequences (CDS), untranslated regions (UTR's), Expressed	**10 Hrs**

	Sequence Tags (EST), Short Tandem Repeats (STR), Single Nucleotide. Polymorphism (SNP), Approach to gene identification, Gene annotation, Gene prediction. Promoter prediction. Overview and applications of Genomics, Comparative genomics, Functional genomics	
III	**Unit 3- Proteomics** Protein structures, Protein folding, Secondary structure prediction methods-Chou-Fasman, GOR, Jpred, Three-dimensional structure prediction Methods; Homology modelling, Threading method, Ab-initio methods. Molecular Visualization using Rasmol, Cn3D, Protein: Introduction, structure, functional diversity, modification, tools to identify protein modifications; Extraction of total Proteins, Overview of Protein Separation Techniques, SDS PAGE, Native PAGE, Preparative PAGE, 2-D gel electrophoresis and its different variants, Image analysis of 2-D gels; Mass Spectrometry, MALDI, peptide mass fingerprinting, Proteome database, Potentials of proteomics in biotechnology : Case studies related to Clinical and biomedical application of proteomics.	**10 Hrs**

Recommended books

1. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins -By: Andreas D. Baxevanis (Ed), B. F. Francis Ouellette (Ed) Publisher: Wiley, John & Sons, Incorporated ISBN: 0471478784
2. Introduction to Bioinformatics- By: Arthur M. Lesk Publisher: Oxford University Press, ISBN: 0199251967
3. Bioinformatics and Functional Genomics-By Jonathan Pevsner Publisher: WileyBlackwell, ISBN: 0470085851.
4. 4. Protein- Protein Interaction-By C. Frieden & L.W. Nichol. Publisher: John Wiley & Sons, Chichester, UK.
5. Introduction to Bioinformatics, (Atwood, T. K. and Parry-Smith, D. J).
6. An introduction to Computational Biochemistry. (C. Stain Tsai, A. John Wiley and Sons, Inc., publications).7. Bioinformatics; Methods and applications; Genomics, Proteomics and Drug Discovery;
7. Rastogi, S. C. and Mendiratta and Rastogi, P. R.M.Twyman, Principles of Proteomics, BIOS Scientific Publishers, 2004.
8. P.Michael Conn, Handbook of Proteomic Method.Humana Press, Totowa, New Jersay, USA, 2003.
9. R. D. Appel and D.F. Hochstrasser, Proteome Research: New Frontiers in Functional Genomics,Springer, 1997

Type of Course :	DSC Major / Mandatory Major course
Course Code:	BIOT/MJ/652-P
Course Title :	Bioinformatics
Teaching method:	Practical
Teaching Scheme :	(Hrs./ Week)4
Contact Hours:	60
Credits Assigned :	2

ModuleNo.	Topics / actual contents of the syllabus
1.	Retrieving sequence information from GenBank database/EMBL by using test based queries.
2.	Protein sequence retrieval from UniprotKb and analysis
3.	Search and retrieval of information from protein secondary database (Prosite, ProRules, study of file arrangement of one record)
4.	Retrieval and analysis of data from protein structural database-PDB
5.	Search and retrieval of information from protein secondary database (Pfam and study of file arrangement of one record)
6.	Searching similar sequences by using BLAST and FASTAtool.
7.	Multiple Sequence alignment using Clustaw
8.	Constructing phylogenetic tree
9.	Protein structure prediction by Homology modelling
10.	Study of protein structure visualization tools

Type of Course:	DSC Major / elective course
Course Code:	BIOT/DSE/653-AT
Course Title:	**Environmental Biotechnology**
Teaching method:	Classroom lectures
Teaching Scheme:	(Hrs./ Week)
Contact Hours:	30
Credits Assigned:	2

Learning Objectives of the Course:

9. To introduce xenobiotic compounds and its microbial degradation
10. To make students aware about different biotechnological processes used while handling waste and waste water
11. To enlighten the students about various types of biotransformation

Course Outcomes (COs):

After completion of the course, students will be able to -

1. Explain the microbial methods for degradation of xenobiotics
2. Explain about waste water and waste handling processes from biotechnological perspective
3. Explain about various types of biotransformations

Module No.	Topics / actual contents of the syllabus	Contact Hours
I	Definition of recalcitrant/ xenobiotic compounds, their presence in the natural ecosystem, Concept and consequences of biomagnification, Microbiology of degradation of xenobiotics in the environment, ecological considerations, decay behaviour, biomagnification and degradative plasmids, hydrocarbons, substituted hydrocarbons, oil pollution, surfactants and pesticides. Genetically Modified Organisms released and its environmental impact assessment and ethical issues.	**10 Hrs**
II	Microbiology of wastewater and solid waste treatment: -Waste-types-solid and liquid waste characterization, physical, chemical, biological, aerobic, anaerobic, primary, secondary and tertiary treatments. Anaerobic processes: Anaerobic digestion, anaerobic filters, and upflow anaerobic sludge. Treatment schemes for effluents of dairy, distillery, tannery, sugar and antibiotic industries (Types, microbes used, types of Effluent Treatment Plants). Biochemistry of nitrate and sulphate reduction with a special reference to waste treatment. Bioconversion of Solid Waste and utilization as fertilizer.	**10 Hrs**
III	Biotransformation- Introduction, types of reactions involved, procedures and applications with respect to steroids, antibiotics and pesticides transformations, Bioaccumulation of heavy metal ions from industrial effluents, Bioleaching of metals, Acid Mine Drainage Bioenergy using microorganisms, Bioethanol, Biomethane, Biodiesel, Biohydrogen	**10 Hrs**

Text Books:

Biotechnology, A text book of Industrial Microbiology, Creuger & Creuger Sinaeur

Associates

Reference Books:

1. Bioremediation by Baker K.H. and Herson D.S. 1994, McGraw Hill Publications, New York.
2. Waste Water Engineering- Treatment, Disposal and Re-use by Metcalf and Eddy, Tata McGraw Hill, New York
3. Pollution: Ecology and Biotreatment by Ec Eldowney S., Hardman D.J. 1993 Longman Scientific Technical.
4. Environmental Microbiology edited by Ralph Mitchell, John Wiley and Sons., New York.
5. Waste Water Microbiolgy, 2 nd Edition by Bitton.
6. Chemistry and Ecotoxicology of Pollution, Edited by Des. W. Connell, G.J. Miller, Wiley Interscience Publications.
7. Environmental Biotechnology Edited by C.F. Forster and D.A. John Wase, Ellis Horwood Ltd.
8. Advances in Waste water Treatment Technologies 1998 Vol. I and II by R.K. Trivedy, Global Science Publications.
9. Biocatalysis and Biodegradation: Microbial transformations of organic compounds. 2000, by Lawrence P. Wacekett, C. Douglas Hershberger, ASM Publications
10. A Manual of Environmental Microbiolgy 2 nd edition 2001 by Christon J. Hurst(Chief Editor), ASM Publications.
11. Biodegradation and Bioremediation, Academic Press, San Diego.

Type of Course:	DSC Major / Elective course
Course Code:	BIOT/DSE/653-AP
Course Title:	**Environmental Biotechnology**
Teaching method:	Practical
Teaching Scheme:	4 (Hrs./ Week)
Contact Hours:	60
Credits Assigned:	2

Learning Objectives of the Course:

1. To introduce xenobiotic compounds and its microbial degradation
2. To make students aware about different biotechnological processes used while handling waste and waste water
3. To enlighten the students about various types of biotransformation

Course Outcomes (COs):

After completion of the course, students will be able to -

1. Explain the microbial methods for degradation of xenobiotics
2. Explain about waste water and waste handling processes from biotechnological perspective
3. Explain about various types of biotransformations

Practical No.	Title of Practical
1	Determination of BOD from waste water
2	Determination of COD from waste water
3	Microbial dye decolorization
4	Physical analysis of industrial effluent by measuring total solids, total dissolved solids and total suspended solids
5	Bacterial reduction of nitrate from groundwaters
6	Biotransformation of toxic chromium into nontoxic by pseudomonas species
7	Isolation of pollutant/xenobiotic degrading bacteria
8	Isolation of plasmid from pollutant/xenobiotic degrading bacteria
9	Microalgal cultivation in wastewater
10	Bioenergy production- Biodiesel from microalgae

Text Books:

Biotechnology, A text book of Industrial Microbiology, Creuger & Creuger Sinaeur Associates

Reference Books:

1. 1. Bioremediation by Baker K.H. and Herson D.S. 1994, McGraw Hill Publications, New York.
2. Waste Water Engineering- Treatment, Disposal and Re-use by Metcalf and Eddy, Tata McGraw Hill, New York
3. Pollution: Ecology and Biotreatment by Ec Eldowney S., Hardman D.J. 1993 Longman Scientific Technical.
4. Environmental Microbiology edited by Ralph Mitchell, John Wiley and Sons., New York.
5. Waste Water Microbiolgy, 2 nd Edition by Bitton.
6. Chemistry and Ecotoxicology of Pollution, Edited by Des. W. Connell, G.J. Miller, Wiley Interscience Publications.
7. Environmental Biotechnology Edited by C.F. Forster and D.A. John Wase, Ellis Horwood Ltd.
8. Advances in Waste water Treatment Technologies 1998 Vol. I and II by R.K. Trivedy, Global Science Publications.
9. Biocatalysis and Biodegradation: Microbial transformations of organic compounds. 2000, by

Lawrence P. Wacekett, C. Douglas Hershberger, ASM Publications
10. A Manual of Environmental Microbiolgy 2 nd edition 2001 by Christon J. Hurst(Chief Editor), ASM Publications.
11. Biodegradation and Bioremediation, Academic Press, San Diego.

Type of Course :	DSE Major/ Elective course
Course Code:	BIOT/DSE/653-BT
Course Title :	**Animal Biotechnology II**
Teaching method:	Classroom lectures
Teaching Scheme :	(Hrs./ Week) 2
Credits Assigned :	2

Course objectives:

1. The objective of this course is to enable students to develop standard skills for animal cell culture.
2. maintenance of cell lines and in vitro application of cell and molecular techniques and also to
3. understand the principles of animal cloning and its applications.

Course outcomes:

Students will be able to

1. Explain the fundamental scientific principles that underlie cell culture
2. Acquire knowledge for isolation, maintenance and growth of cells.
3. Develop proficiency in establishing and maintaining of cell lines.
4. Acquire knowledge in animal cloning and its applications

Module No.	Topics / actual contents of the syllabus	Contact Hours
I	**Introduction to Animal Cell Science** **1.1** Structure and organization of animal cell. Equipments and materials for animal cell culture technology. **1.2** Primary and established cell line cultures. Introduction to the balanced salt solutions and simple growth medium. **1.3** Brief discussion on the chemical, physical and metabolic functions of different constituents of culture medium. Role of carbon dioxide. Role of serum and supplements. Serum and protein free defined media and their applications. Application of animal cell cultur	10
II	**Cell lines and its applications** **2.1** Primary and secondary culture of animal cells: types of primary cell cultures, isolation of tissue and primary culture. **2.2** Subcultured propagation, criteria for subculture and propagation, split ratio, subculture in suspension. **2.3** Basic techniques of mammalian cell culture *in vitro*, disaggregation of tissue and primary culture; maintenance of cell culture; cell separation. **2.4** Scaling- up of animal cell culture.	10
III	**Cell lines and its applications** **3.1** Culture and maintenance of cell lines, Biology and characterization of the	10

	cultured cells, Measurement of viability, **3.2** Model animals in animal biotechnology **3.3** DNA transfer techniques in to mammalian cells, Microinjection, electroporation, Stem cell etc. **3.4** Artificial insemination, IVF, somatic cell nuclear transfer and stem cell technology.	

References

1. Ian, R. Freshney Culture of Animal Cells: A Manual of Basic Technique and Specialized
Applications , 4th Edition, 2000.
2. Ranga, M. M. Animal Biotechnology, 2nd edition, Agrobios, 2007.
3. Masters, J. R. W. Animal Cell Culture, 3rd Edition, Oxford University Press, 2000.
4. Marshak, D. R., Gardner, R. L. and Gottlieb, D. Stem Cell Biology, Volume 40, Cold Spring Harbor Publication, 2001.

Type of Course :	DSE Major / Elective course
Course Code:	BIOT/DSE/653-BP
Course Title :	**Animal Biotechnology -II**
Teaching method:	Practical
Teaching Scheme :	(Hrs./ Week) 4
Credits Assigned :	2

ModuleNo.	**Topics / actual contents of the syllabus**
I	Enumeration of Red Blood cells (RBCs) from sheep and human blood.
II	Isolation of Cells from Liver tissue and its Quantification
III	Cell Viability assay using dye-exclusion method
IV	Micronucleus Assay
V	Hemolytic test for *Staphylococcus aureus*
VI	Con-A induced Hemagglutination Assay
VII	Anchorage independent cell culture(Lymphocyte culture)
VIII	Anchorage dependent cell culture (chick embryo cell culture). Epithelial cell culture
IX	Anti-angiogenic activity using chick chorio-allantoic membrane(CAM) assay
X	Preparation of culture media

Type of Course :	DSE Major/ Elective Course
Course Code:	BIOT/DSE/653-CT
Course Title :	**Synthetic Biology**
Teaching method:	Classroom lectures
Teaching Scheme :	(Hrs./ Week) 2
Contact Hours:	30
Credits Assigned:	2

Course Description:

This course provides an in-depth understanding of synthetic biology, an interdisciplinary branch combining biology, engineering, and computer science to design and construct new biological parts, devices, and systems. The course will cover foundational concepts, key technologies, applications, and ethical considerations of synthetic biology.

Learning Objectives of the Course:

1. To introduce the foundational concepts and methodologies in synthetic biology.
2. To explore the tools and technologies used in designing and constructing synthetic biological systems.
3. To examine the applications and ethical considerations of synthetic biology.

Course Outcomes (COs):

After completion of the course, students will be able to -

1. Understand and apply key concepts and methodologies in synthetic biology.
2. Utilize various tools and technologies for designing and constructing synthetic biological systems.
3. Analyze the applications and implications of synthetic biology in various fields and address ethical considerations.

ModuleNo.	Topics / actual contents of the syllabus	Contact Hours
I	**Unit I: Introduction to Synthetic Biology (1 Credit)** ***Foundations of Synthetic Biology:*** Definition and Scope, Historical Development and Milestones ***Key Concepts and Methodologies:*** Standardization and Modularity, Abstraction Hierarchy: Parts, Devices, Systems, Design-Build-Test Cycle ***Genetic Parts and Circuits:*** Promoters, Ribosome Binding Sites, Coding Sequences, Terminators. Synthetic Gene Networks: Logic Gates and Oscillators ***Case Studies in Synthetic Biology:*** Early Success Stories: Synthesizing Small Molecules and Biomaterials. Famous Projects: The Minimal Genome Project, Synthetic Yeast Chromosome.	**15 Hrs**
II	**Unit II: Tools and Technologies in Synthetic Biology (0.5 Credit)** ***DNA Assembly Techniques:*** Restriction Enzyme Cloning,	**7.5 Hrs**

	Gibson Assembly, Golden Gate Assembly ***Genome Editing Tools:*** CRISPR-Cas Systems, TALENs and Zinc Finger Nucleases ***Computational Tools and Modeling:*** Bioinformatics and Database Resources, Computer-Aided Design (CAD) Tools for Biological Systems, Modeling and Simulation of Synthetic Gene Networks ***Standard Biological Parts and Registry:*** The BioBricks Foundation and the iGEM Competition	
III	**Unit III: Applications and Ethical Considerations (0.5 Credit)** ***Industrial and Environmental Applications:*** Biomanufacturing: Production of Biofuels, Pharmaceuticals, and Chemicals. Environmental Engineering: Bioremediation and Biosensing ***Medical Applications:*** Synthetic Biology in Medicine: Gene Therapy, Synthetic Vaccines, and Engineered Probiotics. Tissue Engineering and Regenerative Medicine ***Ethical, Legal, and Social Implications (ELSI):*** Biosecurity and Biosafety Concerns. Intellectual Property and Patent Issues. Public Perception and Societal Impact ***Future Directions and Challenges:*** Emerging Trends and Technologies. Grand Challenges in Synthetic Biology.	**7.5 Hrs**

Text Books:

Reference Books:

1. "Synthetic Biology: A Primer" by Paul S. Freemont and Richard I. Kitney
2. "Adventures in Synthetic Biology" by Drew Endy and Isadora Deese
3. "Biobuilder: Synthetic Biology in the Lab" by Natalie Kuldell, Rachel Bernstein, and Karen Ingram

Review Articles:

1. "Synthetic Biology: Applications Come of Age" by George M. Church et al. in Nature Reviews Genetics
2. "The Long View on Synthetic Biology" by Drew Endy in Nature
3. "Synthetic Biology: New Engineering Rules for an Emerging Discipline" by Jim Collins in Molecular Systems Biology.

Online Resources :

1. BioBricks Foundation (http://biobricks.org/)
2. iGEM Competition (http://igem.org/)
3. Synthetic Biology Open Language (SBOL) (http://www.sbolstandard.org/)

Scope:

This course provides a comprehensive overview of synthetic biology, emphasizing both theoretical knowledge and practical applications, preparing students for research and careers in this rapidly evolving field.

Type of Course :	DSE Major/ Elective Course
Course Code:	BIOT/DSE/653-CP
Course Title :	Laboratory Course in Synthetic Biology
Teaching method:	Practical
Teaching Scheme :	(Hrs./ Week) 4
Contact Hours:	60
Credits Assigned:	2

Course Description:

This laboratory course provides hands-on experience in synthetic biology techniques, covering the design, construction, and testing of synthetic biological systems. Students will engage in a series of practical exercises to apply their theoretical knowledge in real-world scenarios, using state-of-the-art tools and technologies.

Learning Objectives of the Course:

1. To provide practical experience in synthetic biology techniques and methodologies.
2. To develop skills in designing, constructing, and testing synthetic biological systems.
3. To foster an understanding of the applications and challenges of synthetic biology through hands-on experiments.

Course Outcomes (COs):

By the end of the course, students will be able to: -

1. Apply synthetic biology techniques to construct and test genetic circuits.
2. Use modern tools and software for DNA assembly and genome editing.
3. Analyze the results of synthetic biology experiments and troubleshoot common issues.

ModuleNo.	Topics / actual contents of the syllabus	Contact Hours
I	**List of Practical Exercises:** ***Practical 1: Introduction to Laboratory Safety and Good Practices:*** Overview of lab safety rules and proper handling of biological materials. Sterilization techniques and aseptic handling ***Practical 2: Basic Molecular Biology Techniques:*** DNA extraction from biological samples. PCR amplification of genetic sequences ***Practical 3: DNA Assembly Techniques I:*** Restriction enzyme digestion and ligation. Construction of basic plasmid vectors ***Practical 4: DNA Assembly Techniques II:*** Gibson Assembly method for seamless DNA assembly. Golden Gate Assembly for modular cloning ***Practical 5: Bacterial Transformation:*** Transformation of E. coli with recombinant plasmids. Selection and screening of transformants ***Practical 6: Reporter Gene Assays:*** Construction of	**60 Hrs**

	genetic circuits with reporter genes (e.g., GFP, RFP). Measurement of gene expression using fluorescence assays ***Practical 7: CRISPR-Cas9 Genome Editing:*** Design of gRNAs for target gene editing. Introduction of CRISPR-Cas9 constructs into bacterial cells ***Practical 8: Analysis of Genome Editing Outcomes:*** Screening for successful genome edits using PCR and sequencing. Analysis of on-target and off-target effects ***Practical 9: Synthetic Gene Networks:*** Construction of synthetic gene networks (e.g., toggle switches, oscillators). Testing and characterization of network behavior ***Practical 10: Bioinformatics Tools for Synthetic Biology:*** Introduction to bioinformatics software (e.g., Benchling, SnapGene). In silico design and analysis of synthetic constructs ***Practical 11: Quantitative Analysis of Gene Expression:*** Quantitative PCR (qPCR) for measuring gene expression levels. Data analysis and interpretation ***Practical 12: Metabolic Engineering:*** Design and construction of metabolic pathways in microorganisms Measurement of metabolite production and pathway optimization. ***Practical 13: Synthetic Biology and Bioethics:*** Case studies on ethical considerations in synthetic biology. Discussion on biosafety, biosecurity, and public perception ***Practical 14: Project Design and Proposal Writing: Metabolic Engineering:*** Development of a synthetic biology project proposal. Presentation and peer review of project ideas. ***Practical 15: Final Project Execution and Presentation:*** Execution of a small-scale synthetic biology project. Data analysis, report writing, and oral presentation of results.	

Reference Books:

1. "Synthetic Biology: A Primer" by Paul S. Freemont and Richard I. Kitney
2. "Biobuilder: Synthetic Biology in the Lab" by Natalie Kuldell, Rachel Bernstein, and Karen Ingram

Articles and Protocols:

1. Current Protocols in Synthetic Biology (Wiley)
2. "Synthetic Biology: Methods for Microorganisms" by Jeffrey C. Way et al.

Online Resources:

1. BioBricks Foundation (http://biobricks.org/)
2. iGEM Competition (http://igem.org/)
3. Addgene Protocols (https://www.addgene.org/protocols/)

Scope:

This course aims to provide students with the practical skills and knowledge required to excel in the field of synthetic biology, preparing them for research and industry roles.

Type of Course :	**DSC Major / Elective**
Course Code:	BIOT/DSE/653-DT
Course Title :	**Pharmaceutical Biotechnology**
Teaching method:	**Classroom lectures**
Teaching Scheme :	**2 (Hrs./ Week)**
Contact Hours:	**30**
Credits Assigned :	**2**

Learning Objectives of the Course:

1. The Pharmaceutical Biotechnology course aims to provide students with a comprehensive understanding of the principles and applications of biotechnology in the pharmaceutical industry.
2. Learn how biotechnological techniques are applied in the development and production of pharmaceutical products, such as vaccines, monoclonal antibodies, and gene therapies.
3. Understand the processes involved in the production, purification, and formulation of biopharmaceuticals.

Course Outcomes (COs) :

After completion of the course, students will be able to -

1. Identify the prospects of applying Biotechnological concepts in pharmaceutical applications.
2. Genetic engineering applications in relation to production of pharmaceuticals
3. Understand the importance of pharmaceutical products, such as vaccines, monoclonal antibodies,and gene therapies.

Module No.	Topics / actual contents of the syllabus	Contact Hours
I	**Introduction to Pharmaceutical Biotechnology** General concept of Pharmaceutical Biotechnology and its applications in brief. The Impact of Biotechnology on the Drug Development Process. Biosensors- Working and applications of biosensors in Pharmaceutical Industries. Brief introduction to Protein Engineering. Prokaryotic & Eukaryotic Cells in Biotech Production: • Actinomycetes in Biotech Production, • Fungi in the Production of Statins, Cyclosporine, and ß-Lactam Antibiotics.	**10 Hrs**
II	**Common Pharmaceutical Biotechnological Product** Hybridoma technology- Monoclonal antibodies Production, Purification and Applications. Phage display technology. Therapeutic proteins: Classification based on pharmacological action. In brief study of human Insulin, Thrombin, fibrinogen and cytokines. Recombinant DNA Products: • Recombinant DNA Vaccines • Recombinant DNA Enzymes • Recombinant DNA Growth Hormone • Recombinant DNA Proteins • Recombinant DNA Yeast	**10 Hrs**
III		**10 Hrs**

	Clinical diagnostics and Gene therapy: Emerging clinical diagnostics: Microarrays, FACS, Lab-on-a-Chip approach for molecular diagnosis, Introduction to SELDI-TOF and diagnostic proteomics. Nano-diagnostics. Gene therapy: *Ex vivo*, *In vivo*, *In-situ* gene therapy, Strategies of gene therapy- gene replacement/ augmentation, gene correction, gene editing, gene regulation and silencing. Viral vectors: Adenoviruses, Adeno associated virus, Herpes Simplex virus, Non-viral vectors: Liposomes, Receptor mediated gene transfer, Gene gun. Gene therapy for genetic diseases: Familial Hypercholesterolemia, Cystic Fibrosis. Nano medicine.	

Reference Books:

1. Cellular and Molecular Immunology by Abdul K. Abbas, Andrew H. Lichtman and Shiv Pillai
2. Kuby Immunology by Thomas J. Kindt, Barbara A. Osborne, and Richard A. Goldsby
3. Diagnostic and Therapeutic Antibodies (Methods in Molecular Medicine) by Andrew J.T. George (Editor), Catherine E. Urch (Editor), Publisher: Humana Press; Edition (2000).
4. Molecular Diagnosis of Infectious Diseases (Methods in Molecular Medicine) by Jochen Decker and U. Reischl, Publisher: Humana Press; Edition (2003).
5. Molecular Diagnostics: for the Clinical Laboratorian by Willium B. Coleman, Gregory J. Tsongalis, Publisher : Humana Press; edition (2005).
6. Molecular Diagnostics: Techniques and Applications for the Clinical by Wayne W. Grody, Robert M. Nakamura, Frederick L. Kiechle, Charles Strom, Publisher: Academic Press; Edition (2009).
7. Nanotechnology in Medicine: Toxicity and Safety by Mahendra Rai, Mrunali Patel, Rashmin Patel, Publisher: Wiley; Edition (2021).
8. Nanobiotechnology in Diagnosis, Drug Delivery and Treatment by Mahendra Rai (Editor), Mehdi Razzaghi-Abyaneh (Editor), Avinash P. Ingle (Editor), Publisher: Wiley. Edition (2020).
9. Verma, I. M., & Somia, N. (1997). Gene Therapy: Promises, Problems, and Prospects. Nature, 389(6648), 239-242.
10. Gao, W., & Chan, J. M. (2013). Farokhzad, O. C. pH-Responsive Nanoparticles for Drug Delivery. Molecular Pharmaceutics, 10(11), 4277-4285.
11. Chow, S. C., & Liu, J. P. (Eds.). (2016). Design and Analysis of Clinical Trials: Concepts and Methodologies (3rd ed.). Wiley.
12. Walsh, G. (2014). Biopharmaceuticals: Biochemistry and Biotechnology (2nd ed.). Wiley-Blackwell.
13. Crommelin, D. J. A., & Sindelar, R. D. (Eds.). (2018). Pharmaceutical Biotechnology: Fundamentals and Applications (4th ed.). Springer.
14. https://www.pharmaresearchlibrary.com/wp-content/uploads/2013/03/Pharmaceutical-Biotechnology-Drug-Discovery-and-Clinical-Applications.pdf
15. https://bcrti.co.in/digitallibrary/includeFolder/noticeFolder/21110902334811 4.pdf

16. https://web.xidian.edu.cn/yqxia/files/20140227_103205.pdf
17. file:///D:/Downloads/bk978-0-7503-1299-8ch1.pdf
18. file:///D:/Downloads/Book_Pharmaceutical_Biotechnology_4th_E.pdf
19. https://oasis.iik.ac.id:9443/library/repository/a932eb462c49885a2c72755977036b81.pdf

Scope:

Biotechnology has a long promise to revolutionize the biological sciences and Technology. Biotechnology is leading to new biological revolutions in diagnosis, prevention and cure of diseases, new and cheaper pharmaceutical drugs.

Type of Course :	**DSC Major / Elective**
Course Code:	BIOT/DSE/653-DP
Course Title :	**Pharmaceutical Biotechnology**
Teaching method:	**Laboratory Practical**
Teaching Scheme :	**4 (Hrs./ Week)**
Contact Hours:	**60**
Credits Assigned :	**2**

Course Title: Practical Course on Pharmaceutical Biotechnology

1. Measuring the concentration of nucleic acids and proteins using UV-visible spectrophotometry.
2. Study effect of solvent on wavelength maxima of drugs.
3. TLC mobile phase selection of a various combination of compounds and reaction monitoring.
4. Preparative TLC analysis.
5. Protein Extraction and Purification: Extracting proteins from cells and purifying them using techniques like affinity chromatography.
6. SDS-PAGE: Analysing protein size and purity using sodium dodecyl sulfate-polyacrylamide gel electrophoresis.
7. Western Blotting: Detecting specific proteins using antibody-based techniques.
8. Enzyme-Linked Immunosorbent Assay (ELISA): Quantifying proteins or antibodies using ELISA
9. Quality Control Testing: Performing tests to ensure the quality and consistency of pharmaceutical products.
10. Cell Viability Assays: Assessing cell health and viability using assays trypan blue exclusion.

Type of Course :	**DSE Major / Elective course**
Course Code:	**BIOT/DSE/653-E**
Course Title :	**An Online certification course from NPTEL /SWAYM /MOOC of equivalent credits { with biology basis }**
Teaching method:	**Online Teaching**
Credits Assigned :	**4**

In case a student opts online course as, **BIOT/DSE/653-E** the curriculum, rules, regulations, and scheme of assessment etc of the course conducting agency will be binding of the student. The student should submit the course completion certificate to the department and deposit his/her earned credits in ABC.

Type of Course :	**DSE Major / Elective course**
Course Code:	BIOT/DSE/649-E
Course Title :	**Research Project Stage II**
Teaching method:	**Research work**
Credits Assigned :	**6**

Course description:

This is the 6 credit course which is planned to evaluate course outcomes of research project with specific achievements and competencies that students achieved within given tenure. For this, students will select a research topic related to biotechnology, which may encompass areas such as genetic engineering, molecular biology, bioinformatics, bioprocess engineering, environmental biotechnology, medical biotechnology, or agricultural biotechnology. After completion of project work students are expected to demonstrate upon completing the project work.

Learning Objectives of the Course:

1. To review and study the related parameters of research topic and to follow all necessary experimental steps as mentioned in synopsis.
2. To develop practical skills in creating and evaluating an experimental data and for this to utilize appropriate statistical and computational tools to analyse it accurately.
3. To reach up to a suitable conclusion based on the results of the experiments done during research work.
4. Compilation, submission and Presentation of all data and report of research project work.

Course Outcomes (COs):

After completion of the course, students will be able to -

1. To Review and study research work related with research topic.
2. To develop practical skills in creating and evaluating any experimental data by utilize appropriate statistical and computational tools to analyzeit accurately.
3. Students can reach up to a suitable conclusion based on the results of the experiments done during research work.
4. Compile all results , report submission, Presentation of research their research work done.
5. After successfully going through all the above steps.students will able to publish their research work in an appropriate journal.

General guide lines:

1. At the start of semester students need to summarise the workdone in previous semester.

2. Periodically the students have to discus their progress updates with their project guide.
3. At the end of semester, students would submit and present result, conclusion and outcome of their research work.
4. Evaluation would be done on the basis of punctuality of the students, work done by the student and mode of presentation and report submission done by students.