Dr. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY, AURANGABAD

CIRCULAR NO.SU/Sci. & Tech./Colleges./NEP/23/2023

It is hereby inform to all concerned that, the syllabi prepared by the Board of Studies & Ad-hoc Boards and recommended by the Dean, Faculty of Science & Technology, the Hon'ble Vice-Chancellor has accepted **the following curriculum of All Post Graduate Degree Courses as per Norms of National Education Policy – 2020 under the Faculty of Science & Technology run to the Affiliated Colleges, Dr.Babasaheb Ambedkar Marathwada University** in his emergency powers under section 12(7) of the Maharashtra Public Universities Act, 2016 on behalf of the Academic Council as appended herewith.

Sr.No.	Syllabi of Affiliated BAMU, Aurangabad.	Semester
1.	M.Sc. Biotechnology	Ist and IInd Semester
2.	M.Sc.Forensic Science.	Ist and IInd Semester
3.	M.Sc Forensic Cyber.	Ist and IInd Semester
4.	One Year PG Diploma in Forensic Sci. & Realated Law	Ist and IInd Semester
5.	One Year PG Diploma in Digital and Cyber Forensic and Related Law.	Ist and IInd Semester
6.	M.Sc. in Applied Physics and Ballistics	Ist Semester
7	M.Sc.Forensic Toxicology.	Ist Semester

This is effective from the Academic Year 2023-24 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/NEP/2023/10092-100
Date:- 16.08.2023.

★ ★ ★ ★ ★ ★★★★★

Deputy Registrar,
Academic Section

Copy forwarded with compliments to :-

1] **The Principal of all concerned affiliated 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.BAMU,A'bad.
2] The Section Officer,[M.Sc.Unit] Examination Branch,Dr.BAMU,A'bad.
3] The Programmer [Computer Unit-1] Examinations, Dr.BAMU,A'bad.
4] The Programmer [Computer Unit-2] Examinations, Dr.BAMU,A'bad.
5] The In-charge,[E-Suvidha Kendra], Rajarshi Shahu Maharaj Pariksha Bhavan, Dr.BAMU,A'bad.
6] The Public Relation Officer, Dr.BAMU,A'bad.
7] The Record Keeper, Dr.BAMU,A'bad.

DR. BABASAHEB AMBEDKAR MARATHWADA UNIVERSITY, AURANGABAD.

(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 2023-24)

For

Subject: --Biotechnology

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. Inclusivity 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.

Course Structure

Two-Year Post-graduate Program

Course and Credits Distribution of Two years 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 Complete during summer break		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								

ABBREVIATION:

Major: A course, which should compulsorily be studied by the student as requirement of core or major subject is termed as a core course.

DSE: Generally, a course which can be chosen from a pool of course and which may be very specific or specialized or advanced or supportive to the discipline/subject of study or which provides an extended scope or which enables an exposure to some other discipline/subject/domain or nurtures the candidates proficiency/skill is called as elective course.

OJT: On-the- Job Training

FP: Field Project/Internship/Apprenticeship (Corresponding to the Major (Core) Subject

RP:-Research Project Corresponding to the Major (Core) Subject

Note- Master Programme is based on DSC Specialization

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.

AS PER NEP 2020

Illustrative Credit distribution structure for Two YearsPG Programme with Multiple Entry and Exit options.

Class: M.Sc. First Year

Semester: First Semester 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/500-T	**Microbiology and Virology**	2	-	2	-	4+4+4 +2=14
	BIOT/MJ/500-P	Lab Course Based On BIOT/MJ/500- T	-	4	-	2	
	BIOT/MJ/501-T	**Biomolecules and Bioenergetics**	2	-	2	-	
	BIOT/MJ/501-P	Lab Course Based On BIOT/MJ/501- T	-	4	-	2	
	BIOT/MJ/502-T	**Inheritance Biology**	2	-	2	-	
	BIOT/MJ/502-T	Lab Course Based On BIOT/MJ/502- T	-	4	-	2	
	BIOT/MJ/503-P	**Skills In Biotechnology** I	2	-	2	-	
DSE (Choose any one from pool of courses)	BIOT/DSE/504 -AT	Techniques In Biotechnology	2	4	2	2	4
	BIOT/MJ/504- AP	Lab Course Based On BIOT/MJ/504- A					
	BIOT/DSE/504-BT	Plant Biotechnology					
	BIOT/DSE/504-BP	Lab Course Based On BIOT/MJ/504- BT					
	BIOT/DSE/504-CT	Bioinformatics and Big Data Analysis					
	BIOT/DSE/504-CP	Lab Course Based On BIOT/MJ/504- CT					
	BIOT/DSE/504-DT	Biopharmaceuticals Science					
	BIOT/DSE/504-DP	Lab Course Based On BIOT/MJ/504- DP					
	BIOT/DSE/504-E	(MOOC Course) Or any Online certification course from NPTEL /SWAYM /MOOC of equivalent credits { with biology basis }					
RM	BIOT/RM/505	**Research Methodology**	4	-	4	-	4
			14	16	14	08	22 credits

EXPLAINATION OF CODE:

BIOT=BIOTECHNOLOGY, MJ=Discipline Specific Core, Major/Mandatory; RM= RESEARCH METHADOTOGY; T= THEORY, P=PRACTICAL;500-549- COURSE CODE AS PER GUIDELINE

M Patil

AS PER NEP 2020

Illustrative Credit distribution structure for Two Years PG Programme with Multiple Entry and Exit options –

Class: M.Sc. First Year

Semester: Second Semester 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/550-T	**Immunology**	2	-	2	-	4+4+4 +2=14
	BIOT/MJ/550-P	Lab Course Based On BIOT/MJ/550- T	-	4	-	2	
	BIOT/MJ/551-T	**Enzyme Technology**	2	-	2	-	
	BIOT/MJ/551-P	Lab Course Based On BIOT/MJ/551- T	-	4	-	2	
	BIOT/MJ/552-T	**Molecular Biology**	2	-	2	-	
	BIOT/MJ/552-P	Lab Course Based On BIOT/MJ/552- T	-	4	-	2	
	BIOT/MJ/553-T	**Skills In Biotechnology II**	2	-	2	-	
DSE (Choose any one from pool of courses)	BIOT/DSE/554-AT	Cell & Developmental Biology	2	4	2	2	4
	BIOT/DSE/554-AP	Lab course based on BIOT/DSE/554-AT					
	BIOT/DSE/554-BT	Genomics and data Sciences					
	BIOT/DSE/554-BP	Lab course based on BIOT/DSE/554-BT					
	BIOT/DSE/554-CT	Animal Biotechnology					
	BIOT/DSE/554-CP	Lab course based on BIOT/DSE/554-CT					
	BIOT/DSE/554-DT	Drug Discovery and Development					
	BIOT/DSE/554-DP	Lab course based on BIOT/DSE/554-DT					
	BIOT/DSE/554-E	(MOOC Course) Or any Online certification course from NPTEL /SWAYM /MOOC of equivalent credits with biology basis					
	BIOT/ OJT/FP /555	On The Job Training/Field Project	4	-	4	-	4
			14	16	14	08	22 credits

EXPLAINATION OF CODE:
BIOT=BIOTECHNOLOGY, MJ=Discipline Specific core, Major/Mandatory; RM= RESEARCH METHADOTOGY; T= THEORY, P= PRACTICAL; 550-600 - COURSE CODE AS PER GUIDELINES

M.Sc. Biotechnology
Semester I

Type of Course :	DSC Major / Mandatory Major course
Course Code:	BIOT/MJ/500-T
Course Title :	Microbiology and Virology
Teaching method:	Classroom lectures
Teaching Scheme :	(Hrs./ Week) 2
Contact Hours:	30
Credits Assigned :	2

Course Title: Microbiology and Virology

Key Objectives:

- To provide students with a comprehensive understanding of microorganisms, including bacteria, viruses, fungi, and protozoa, and their relevance in biotechnology, medicine, and industry.
- To introduce students to the principles of microbial physiology, genetics, and ecology, and their role in biotechnological applications.
- To familiarize students with the molecular and cellular mechanisms of viral replication, pathogenesis, and their impact on human health.
- To explore the latest advancements in microbiology and virology research, including antimicrobial resistance, virotherapy, and vaccine development.

Intended Outcomes:

- Students will gain a deep understanding of microbial diversity, structure, and function, enabling them to identify and characterize different microorganisms in various environments.
- Graduates will be proficient in explaining microbial growth kinetics, nutrient utilization, and their applications in biotechnological processes, such as fermentation and bioremediation.
- Students will be capable of analyzing viral life cycles, including attachment, entry, replication, and release, and their implications in viral diseases and antiviral strategies.
-

Unit I: Basics of Microbiology –

History of Microbiology and theories of Spontaneous generation. Differences between prokaryotic and eukaryotic cells. Types of Microorganisms: Protozoa, Algae, Fungi, Bacteria, Viruses. Stain and staining: Classification of stains, Staining Techniques, Negative, Monochrome and Differential techniques (Gram, capsule spore & acid-Fast staining). Bacterial taxonomy: conventional and molecular approaches, including ribotyping, rRNA sequencing. Identification of microbial communities by metagenome analysis.

Unit II: Microbial Diversity, Growth, and Control - 0.5 credits

Introduction to diversity among Microorganisms. Biogeochemical cycles and microbial involvement (e.g., Sulphate reducers & Sulfur oxidizers). Extremophiles: Survival mechanisms and importance (thermophiles, psychrophiles, methanogens, alkalophiles, acidophiles, halophiles). Role of microorganisms in agriculture, human and animal health, industries, food processing, and bioremediation. Definition of growth, bacterial cell division, generation time, specific growth rate. Mathematical expression of growth and growth curves. Effect of environmental factors on microbial growth. Control of microorganisms by physical & chemical agents, antimicrobial chemotherapy. Pure culture techniques, microbial nutrition, culture media, culture collection, and sporulation.

Unit III: General Virology & Bacteriophage-

Classification, Nomenclature, General Properties, Morphology, and Ultra Structure of Viruses. Cultivation, Purification & Enumeration of Viruses, Viriods & Prions. Structure & Organization of Bacteriophage. Genome Organization, Infection, Multiplication, and Replication of T4 Phage, λ Phage, M13 Phage, Mu Phage. Genetic Switch of λ Phage.

References:

1. Stenier R.Y et al., General microbiology Mc Millan Press. Inc.
2. Pelczar., Reid et al., Microbiology, TMH Publication.
3. Madigan M.T.,et al Brock biology of microorganisms J prenctice hall Inc.
4. Johri B.N Extremeophiles. Springer Verlag, NY
5. Talaro; Foundations in Microbiology.
6. Ananthanarayan; Textbook of microbiology. Orient Longman Delhi
7. Cappucinno; Microbilogy – a laboratory manual. 4th ed.
8. Harrigan W.E., Laboratory methods in Food Microbiology, AcademicPress
9. Toratora, Funke & Care Microbiology: An Introduction
10. Salley A.J Fundamental Principles of Bacteriology
11. Atlas R.M. Principles of Microbiology
12. Methods in Microbiology series
13. Bergys Manual Vol 1-4

M.Sc. Biotechnology Semester I	
Type of Course :	DSC Major / Mandatory Major course
Course Code:	BIOT/MJ/500-P
Course Title :	Microbiology and Virology
Teaching method:	Laboratory Practical
Contact Hours	60
Teaching Scheme :	4 Hrs./ Week
Credits Assigned :	2

Unit I: Microbial Techniques

1. Microscopic Examination:
   - Preparation and observation of microbial specimens using light microscopy.
   - Phase contrast microscopy for visualizing unstained living cells.
2. Microbial Staining Techniques:
   - Gram staining and observation of Gram-positive and Gram-negative bacteria.
   - Acid-fast staining for detecting acid-fast bacteria.
   - Capsule staining and visualization of bacterial capsules.
   - Spore staining to identify bacterial spores.
3. Pure Culture Techniques:
   - Isolation of microorganisms using streak plate and pour plate methods.
   - Sub-culturing and maintenance of pure cultures.
4. Biochemical Characterization:
   - Performing biochemical tests to identify and differentiate bacteria.

Unit II: Microbial Growth and Control

1. Measurement of Microbial Growth:
   - Determination of bacterial growth curve through viable cell count and turbidity measurements.
   - Calculation of generation time and specific growth rate.
2. Effect of Environmental Factors on Microbial Growth:
   - Investigating the influence of temperature, pH, osmolarity, and oxygen on microbial growth.
3. Antimicrobial Sensitivity Testing:
   - Performing disk diffusion or broth dilution methods to assess antibiotic susceptibility.
4. Antimicrobial Control:
   - Evaluating the effectiveness of physical and chemical agents in microbial control.

Unit III: Virology and Bacteriophage Techniques

1. Viral Cultivation and Enumeration:
   - Enumeration of viruses by plaque assay or other methods.
2. Bacteriophage Techniques:
   - Isolation and identification of bacteriophages from environmental samples.
   - Characterization of bacteriophages, including host range determination.

References:

1. Benson's Microbiological Applications: Laboratory Manual in General Microbiology by Alfred E. Brown and Heidi Smith: This lab manual provides a comprehensive set of experiments and exercises covering various aspects of microbiology, including microscopy, staining techniques, pure culture techniques, biochemical characterization, and more.
2. A Photographic Atlas for the Microbiology Laboratory by Michael J. Leboffe and Burton E. Pierce: This lab manual features high-quality photographs and detailed instructions for numerous practical exercises in microbiology, including microscopy, staining techniques, and microbial culture methods.
3. Microbiology: Laboratory Theory & Application by Michael J. Leboffe and Burton E. Pierce: This lab manual is designed to accompany a general microbiology course and includes a wide range of practical experiments covering microbial techniques, growth, and control.
4. Microbiology: A Laboratory Manual by James G. Cappuccino and Natalie Sherman: This lab manual offers a diverse selection of experiments that allow students to explore different aspects of microbiology, including culture techniques, biochemical tests, and virology.
5. Brock Biology of Microorganisms by Michael T. Madigan, Kelly S. Bender, Daniel H. Buckley, W. Matthew Sattley, and David A. Stahl: While not a lab manual, this textbook includes practical applications and examples relevant to microbiology and virology, providing students with a comprehensive understanding of the subject.
6. Laboratory Exercises in Microbiology by John P. Harley: This lab manual offers a wide range of practical exercises, including those related to microbial growth, control, virology, and bacteriophage techniques.
7. Microbiology Laboratory Manual by Cappuccino and Sherman: Another lab manual by the same authors with practical exercises in microbiology and virology suitable for a postgraduate course.
8. Experiments in Microbiology, Plant Pathology, and Biotechnology by K. R. Aneja: This lab manual covers various microbiology and biotechnology experiments, including virology techniques.

M.Sc. Biotechnology
Semester I

Type of Course :	DSC Major / Mandatory Major course
Course Code:	BIOT/MJ/500-T
Course Title :	**Biomolecules and Bioenergetics**
Teaching method:	Classroom lectures
Teaching Scheme :	(Hrs./ Week) 2
Contact Hours:	30
Credits Assigned :	2

Key Objectives:

- To provide students with a comprehensive understanding of the structure, functions, and properties of biomolecules in biotechnological applications.
- To introduce students to the principles of bioenergetics and metabolic pathways involved in cellular processes.
- To familiarize students with the role of biomolecules and bioenergetics in various biotechnological processes, including biopharmaceutical production, biofuel generation, and metabolic engineering.
- To explore the latest advancements and emerging trends in biomolecular research and bioenergetics in the context of biotechnology.

Intended Outcomes:

- Students will gain a deep understanding of the fundamental biomolecules, including proteins, nucleic acids, carbohydrates, and lipids, and their relevance in biotechnological research and applications.
- Graduates will be proficient in explaining the structure-function relationships of biomolecules and their significance in biochemical reactions and cellular processes.
- Students will be able to identify and analyze metabolic pathways and energy conversion mechanisms involved in biotechnological processes.

Unit 1: Introduction to Biomolecules (0.5 credits)

Biomolecules: Definition, classification, and relevance in biotechnology applications. Structure and function of carbohydrates, lipids, and proteins with biotechnological significance. Overview of biomolecules used in biotechnological processes.

Unit 2: Bioenergetics and Metabolic Engineering (0.5 credits)

Cellular energy metabolism in the context of biotechnological applications. Metabolic engineering approaches to enhance energy production and biomolecule synthesis.

Biomolecules in Biopharmaceuticals (0.5 credits): Role of biomolecules in the development of biopharmaceutical products. Production and purification of recombinant proteins and therapeutic antibodies. Biotechnological applications of nucleic acids in gene therapy: Small interfering RNA (siRNA) and microRNA (miRNA) in gene silencing

Unit 3: Photosynthesis and Bioenergy (0.5 credits)

Harnessing photosynthesis for sustainable bioenergy production. Bioenergy crops and genetic modification for improved energy yield. Biotechnological advancements in algal biofuel production. Plant metabolic Engineering: enhancement of plant secondary metabolites or the production of high-value compounds in crops

References

1. Berg, J. M., Tymoczko, J. L., Gatto, G. J. (2019). Biochemistry (9th ed.). W. H. Freeman.
- This comprehensive biochemistry textbook covers biomolecules and their relevance in biological processes.

2. Nelson, D. L., Cox, M. M. (2019). Lehninger Principles of Biochemistry (7th ed.). W. H. Freeman.
- Another excellent textbook that covers biomolecules, bioenergetics, and their importance in cellular processes.

3. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2002). Molecular Biology of the Cell (4th ed.). Garland Science.
- This cell biology textbook includes topics on bioenergetics and cellular energy metabolism.

4. Voet, D., Voet, J. G., Pratt, C. W. (2016). Fundamentals of Biochemistry: Life at the Molecular Level (5th ed.). Wiley.
- A comprehensive biochemistry textbook that covers biomolecules, enzymology, and bioenergetics.

5. Nielsen, J. (2017). Systems Biology for Biotechnologists. CRC Press.
- This book focuses on the application of systems biology principles in biotechnological processes.

6. Wong, D. C. J., Gibson, S. I. (2018). Plant Sugar Signaling: Methods and Protocols. Springer.
- A reference book with methods and protocols related to biomolecules in plants, including sugars and bioenergetics.

M.Sc. Biotechnology
Semester I

Type of Course :	**DSC Major / Mandatory Major course**
Course Code:	**BIOT/MJ/501-P**
Course Title :	**Biomolecules and Bioenergetics**
Teaching method:	**Laboratory Practical**
Contact Hours	**60**
Teaching Scheme :	**4 Hrs./ Week**
Credits Assigned :	**2**

Course Title: Practical in Biomolecules and Bioenergetics

Key Objectives:

- To provide students with hands-on experience in enzyme assays, cellular respiration, and biofuel production.
- To familiarize students with advanced analytical techniques for biomolecule analysis and bioenergetics studies.
- To develop practical skills in designing and conducting experiments related to biomolecules and bioenergetics.

Intended Outcomes:

- Students will gain practical proficiency in conducting enzyme activity assays and analyzing bioenergetic processes.
- Graduates will be skilled in using advanced analytical instruments for biomolecule analysis and characterization.
- Students will be prepared to contribute to research in biotechnology, bioenergy, and metabolic engineering.

1. Qualitative analysis of carbohydrates, lipids, proteins, and nucleic acids using biochemical tests.
2. Quantitative estimation of biomolecules using spectrophotometric assays.
3. Gel electrophoresis of biomolecules for size separation and identification.
4. Enzyme activity assays: Measuring enzymatic reactions using colorimetric or fluorescence-based methods.
5. Investigating the effect of temperature and pH on enzyme activity.
6. Studying the kinetics of enzyme-catalyzed reactions.
7. Isolation of mitochondria from cells and assessment of respiratory activity.
8. Measurement of ATP production during cellular respiration using luminescence-based assays.
9. Determining photosynthetic rates using oxygen evolution or carbon dioxide uptake assays.
10. Evaluating the efficiency of bioenergy production from different sources (e.g., algae, biofuel crops).

References

1. Nelson, D. L., Cox, M. M. (2019). Lehninger Principles of Biochemistry (7th ed.). W. H. Freeman.
2. Smith, P. K., Krohn, R. I., Hermanson, G. T., Mallia, A. K., Gartner, F. H., Provenzano, M. D., ... & Klenk, D. C. (1985). Measurement of protein using bicinchoninic acid. Analytical Biochemistry, 150(1), 76-85.
3. Bergmeyer, H. U. (1983). Methods of Enzymatic Analysis (3rd ed.). Verlag Chemie.
4. Johnson, M. L., & Knapp, D. W. (1982). Enzyme kinetics. Biochemistry, 21(19), 4523-4528.
5. Scaduto Jr, R. C., & Grotyohann, L. W. (1999). Measurement of mitochondrial membrane potential using fluorescent rhodamine derivatives. Biophysical Journal, 76(1), 469-477.
6. Zhao, J., Li, R., & Ackerman, C. M. (2016). Genome-scale carbon and energy metabolism reconstruction for the model diatom Phaeodactylum tricornutum. Frontiers in Plant Science, 7, 131.
7. Blankenship, R. E., Tiede, D. M., Barber, J., Brudvig, G. W., Fleming, G., Ghirardi, M., ... & Fleming, G. R. (2011). Comparing photosynthetic and photovoltaic efficiencies and recognizing the potential for improvement. Science, 332(6031), 805-809.
8. Singh, J., Sharma, N., Sharma, M. S., & Kumar, R. (2018). Biotechnological approach of algae to generate bioenergy-a review. Biocatalysis and Agricultural Biotechnology, 13, 100-109.

M.Sc. Biotechnology
Semester I

Type of Course :	DSC Major / Mandatory Major course
Course Code:	BIOT/MJ/502-T
Course Title :	Inheritance Biology
Teaching method:	Classroom lectures
Contact Hours:	30
Teaching Scheme :	(Hrs./ Week) 2
Credits Assigned :	2

Key Objectives:

- To provide students with a comprehensive understanding of the principles of inheritance and genetic variation in organisms.
- To introduce students to the molecular basis of inheritance, including DNA structure, replication, transcription, and translation.
- To familiarize students with the mechanisms of Mendelian and non-Mendelian inheritance, gene regulation, and genetic disorders.

Intended Outcomes:

- Students will gain a deep understanding of the principles of Mendelian genetics, including Punnett squares, pedigree analysis, and genetic inheritance patterns.
- Graduates will be proficient in explaining the molecular basis of DNA replication, transcription, and translation, and the regulation of gene expression.
- Students will be capable of analyzing genetic disorders, chromosomal aberrations, and the inheritance of complex traits.

Unit 1: Introduction to Mendelian Genetics

The historical background of genetics: Mendel's experiments and laws. Patterns of inheritance: Monohybrid and dihybrid crosses. Extensions of Mendelian genetics: Incomplete dominance, codominance, and multiple alleles.

Unit 2: Molecular Basis of Inheritance

Genes and chromosomes: Linkage, recombination, and gene mapping. Mutation and its role in genetic variation: Types of mutations, Molecular mechanisms of mutation, Role of mutation in genetic variation and evolution, Mutations and single gene disorders, Mutations in non-coding regions, Role of mutations in complex traits and polygenic inheritance.

Unit 3: Chromosomal Basis of Inheritance

Chromosome structure and behavior during mitosis and meiosis. Sex determination and sex-linked inheritance. Genetic disorders related to chromosomal abnormalities. **Population Genetics and Evolution (0.5 credits):** Hardy-Weinberg equilibrium and factors affecting genetic equilibrium. Microevolution: Natural selection, genetic drift, gene flow, and mutation. Macroevolution: Speciation and patterns of evolution.

References

Unit 1: Introduction to Mendelian Genetics
Reference: Mendel, G. (1866). Versuche über Pflanzen-Hybriden. Verhandlungen des naturforschenden Vereines in Brünn, Bd. IV für das Jahr, 3-47.
Book: Snustad, D. P., & Simmons, M. J. (2015). Principles of Genetics (6th ed.). Wiley.

Unit 2: Molecular Basis of Inheritance
Reference: Watson, J. D., & Crick, F. H. (1953). Molecular Structure of Nucleic Acids: A Structure for Deoxyribose Nucleic Acid. Nature, 171(4356), 737-738.
Book: Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2002). Molecular Biology of the Cell (4th ed.). Garland Science.

Unit 3: Chromosomal Basis of Inheritance
Reference: McClintock, B. (1929). A Cytological and Genetical Study of Triploid Maize. Genetics, 14(2), 180-222.
Book: Griffiths, A. J. F., Wessler, S. R., Carroll, S. B., & Doebley, J. (2014). Introduction to Genetic Analysis (11th ed.). W. H. Freeman.

Population Genetics and Evolution
Reference: Hardy, G. H. (1908). Mendelian Proportions in a Mixed Population. Science, 28(706), 49-50.
Book: Hartl, D. L., & Clark, A. G. (2007). Principles of Population Genetics (4th ed.). Sinauer Associates.

M.Sc. Biotechnology Semester I	
Type of Course :	DSC Major / Mandatory Major course
Course Code:	BIOT/MJ/502-P
Course Title :	Inheritance Biology
Teaching method:	Laboratory Practical
Contact Hours	60
Teaching Scheme :	4 Hrs./ Week
Credits Assigned :	2

Unit 1: Mendelian Genetics
Mendelian inheritance patterns: Monohybrid and dihybrid crosses.
Experimental verification of Mendel's laws using model organisms (e.g., Drosophila, pea plants).
Data analysis and interpretation of genetic ratios.

Unit 2: Molecular Genetics Techniques
DNA extraction from plant or animal samples.
Polymerase chain reaction (PCR) for amplifying genetic markers.
Agarose gel electrophoresis to analyze DNA fragments.

Unit 3: Chromosome Analysis
Preparation of chromosome spreads from cell cultures.
Staining techniques (e.g., Giemsa staining) to visualize chromosome structures.
Analysis of chromosomal abnormalities and sex chromosomes.

Population Genetics and Evolution
Hardy-Weinberg equilibrium simulation and calculation of allele frequencies.
Analysis of genetic variation in a population using molecular markers (e.g., DNA sequencing, SNP analysis).
Phylogenetic tree construction based on genetic data.

References

Unit 1: Mendelian Genetics
1. Book: Hartl, D. L., & Clark, A. G. (2007). Principles of Population Genetics (4th ed.). Sinauer Associates.
- This book covers the principles of population genetics, including Mendelian genetics, gene frequencies, and genetic variation.

2. Online Resource: Khan Academy - Mendelian and Non-Mendelian Inheritance
- The Khan Academy website offers a series of interactive tutorials and videos on Mendelian and non-Mendelian inheritance patterns.

Unit 2: Molecular Genetics Techniques
1. Book: Sambrook, J., Russell, D. W. (2006). Molecular Cloning: A Laboratory Manual (3rd ed.). Cold Spring Harbor Laboratory Press.

- This classic manual provides protocols for DNA extraction, PCR, and agarose gel electrophoresis.

2. Online Resource: New England Biolabs (NEB) - Molecular Biology Techniques
- NEB's website offers detailed protocols and resources for various molecular biology techniques, including PCR and DNA gel electrophoresis.

Unit 3: Chromosome Analysis
1. Book: Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2002). Molecular Biology of the Cell (4th ed.). Garland Science.
- This textbook provides information on cellular biology, including chromosome structure and cell division.

2. Online Resource: The Jackson Laboratory - Chromosome Spreading Protocol
- The Jackson Laboratory website offers a detailed protocol for preparing chromosome spreads from cell cultures.

Population Genetics and Evolution
1. Book: Gillespie, J. H. (2004). Population Genetics: A Concise Guide (2nd ed.). Johns Hopkins University Press.
- This concise guide covers population genetics concepts, including Hardy-Weinberg equilibrium and genetic variation.

2. Online Resource: Bioinformatics.org - Phylogenetic Analysis Tools
- The Bioinformatics.org website offers various tools and software for constructing phylogenetic trees based on genetic data.

M.Sc. Biotechnology
Semester I

Type of Course :	DSE Major / Mandatory Major course
Course Code:	BIOT/MJ/503-P
Course Title :	Skills in Biotechnology-I
Teaching method:	Classroom Teaching
Contact Hours	30
Teaching Scheme :	2 Hrs./ Week
Credits Assigned :	2

Skills in Biotechnology I: Good Manufacturing Practice (GMP)

Course Description:

This course introduces students to the principles and practices of Good Manufacturing Practice (GMP) in the biotechnology industry. Students will gain insights into the regulations, standards, and quality control measures essential to produce safe and effective biotechnological products.

Course Credits: 2

Course Objectives:

By the end of this course, students should be able to:

- **Foundational Knowledge:** Develop a solid understanding of the principles, concepts, and regulatory frameworks that underpin Good Manufacturing Practice (GMP) in the biotechnology industry.
- **Practical Application:** Gain the skills to implement GMP standards and practices effectively, including facility design, equipment validation, quality control, and documentation, ensuring the production of safe and consistent biotechnological products.
- **Regulatory Compliance:** Learn how to navigate and adhere to regulatory guidelines, conduct thorough quality control testing, manage deviations, and implement corrective actions, ultimately contributing to the achievement of high-quality standards and ethical practices in biotechnology manufacturing.

Course Outcome:

By successfully completing this course, students will acquire a comprehensive understanding of Good Manufacturing Practice (GMP) principles and their practical application in the biotechnology industry. Students will be equipped with the necessary skills to ensure the production of safe, effective, and high-quality biotechnological products while adhering to regulatory standards and ethical considerations.

Unit I: Introduction to GMP and Regulatory Framework

Introduction to Good Manufacturing Practice (GMP). Regulatory Authorities and Guidelines for GMP. GMP vs. GLP and GCP. **GMP Implementation and Facility Design:** Quality Management Systems and Documentation. Facility Design and Layout for GMP Compliance. Equipment Validation and Maintenance

Unit II: Manufacturing Processes, Quality Control, and Compliance

Raw Material Control and Supplier Qualification. Process Validation and Control Strategies. Cleanrooms, Contamination Control, and Environmental Monitoring. Quality Control Testing and Analytical Methods. Deviations, Investigations, and Corrective Actions

Unit III: Product Quality Assurance and Post-Market Surveillance

Product Release and Quality Assurance. Stability Testing and Product Lifecycle Management. Regulatory Inspections and Audits

References:

Reference Books:

1. "Good Manufacturing Practices for Pharmaceuticals: A Plan for Total Quality Control" by Sidney H. Willig and James R. Stoker

2. "Pharmaceutical Manufacturing Handbook: Regulations and Quality" by Shayne Cox Gad

3. "Validation of Active Pharmaceutical Ingredients, Second Edition" by Ira R. Berry and Robert A. Nash

4. "GMP for Pharmaceuticals" by Manohar A. Potdar

5. "A Practical Guide to FDA's Food and Drug Law and Regulation" by Kenneth R. Piña

Review Articles:

1. Märtlbauer, E. (2017). Good Manufacturing Practices for Food Safety. Comprehensive Reviews in Food Science and Food Safety, 16(3), 399-414.
[Link](https://onlinelibrary.wiley.com/doi/full/10.1111/1541-4337.12267)

2. Haq, N., Yousuf, R. I., & Sohail, M. (2017). Good Manufacturing Practices (GMP) for Pharmaceuticals. Journal of Basic and Applied Sciences, 13(1), 29-36.
[Link](http://nexusacademicpublishers.com/uploads/files/JBAS_421.pdf)

3. Mohiuddin, M., & Rubayet-Ul-Alam, A. S. M. (2019). Good manufacturing practices (GMP) in pharmaceutical manufacturing. World Journal of Pharmaceutical Research, 8(9), 1-10.
[Link](https://www.wjpr.net/admin/assets/article_issue/1568678501.pdf)

M.Sc. Biotechnology
Semester I

Type of Course :	**DSE Major / Elective course**
Course Code:	**BIOT/DSE/504-AT**
Course Title :	**Techniques in Biotechnology**
Teaching method:	**Classroom teaching**
Teaching Scheme :	**2 Hrs./ Week**
Contact Hours:	**30**
Credits Assigned :	**2**

Course Description:

This course provides an in-depth exploration of advanced laboratory techniques used in the field of medical biotechnology. Students will learn practical skills essential for conducting cutting-edge research and applications in medical diagnostics, therapeutics, and personalized medicine.

Course Objectives:

By the end of the course, students should be able to:

1. Understand the theoretical foundations and principles underlying advanced techniques in medical biotechnology.

2. Apply key laboratory skills to perform advanced experiments in medical diagnostics, therapeutics, and molecular medicine.

3. Analyze and interpret experimental data generated using advanced biotechnology techniques.

Outcomes of the Course:

1. Develop proficiency in performing advanced laboratory techniques relevant to medical biotechnology applications.
2. Apply critical thinking skills to design and execute experiments for medical diagnostics, therapeutics, and molecular medicine.
3. Gain an understanding of the ethical, regulatory, and safety considerations in medical biotechnology research.
4. Acquire knowledge of emerging trends and technologies in medical biotechnology and their potential impact on healthcare.

Unit I: Molecular Diagnostics and Genetic Testing

PCR-Based Diagnostics: Realtime PCR, quantitative PCR, and allele-specific PCR for genetic testing. DNA Sequencing: Sanger sequencing, next-generation sequencing (NGS), and applications in clinical genomics. Microarray Technology: Gene expression profiling, SNP analysis, and diagnostic applications.

Unit II: Therapeutic Biotechnology

Recombinant Protein Therapeutics: Expression systems, protein purification, and applications in biopharmaceuticals. Gene Therapy: Viral and nonviral vector-mediated gene delivery, challenges, and clinical applications. RNA-Based Therapeutics: siRNA, miRNA, and antisense oligonucleotides for targeted gene regulation.

Unit III: Molecular Diagnostics and Personalized Medicine

Biomarker Discovery: Identification and validation of biomarkers for disease diagnosis and prognosis. Companion Diagnostics: Integration of molecular diagnostics with targeted therapies for personalized medicine. CRISPR-Cas9 in Medicine: Genome editing for disease modelling, drug discovery, and potential therapies.

References

Some recommended books and articles for learning the course "Techniques in Biotechnology" with a focus on advanced laboratory skills in Medical Biotechnology:

Reference Books:

1. "Molecular Biology of the Cell" by Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter.
   This comprehensive book covers various molecular biology techniques and principles applicable to medical biotechnology.
2. "Medical Biotechnology" by Judit Pongrácz, Katalin Karikó, Drew Weissman, and John J. Rossi.
   This book explores the application of biotechnology in medicine, including molecular diagnostics, gene therapy, and personalized medicine.
3. "Biotechnology for Beginners" by Reinhard Renneberg, Arnold L. Demain, and Dietmar Schomburg.
   This introductory book provides an overview of biotechnological techniques used in various fields, including medical applications.
4. "Gene Cloning and DNA Analysis: An Introduction" by T.A. Brown.
   This book covers essential techniques in gene cloning, PCR, DNA sequencing, and genetic analysis.
5. "Introduction to Genetic Analysis" by Anthony J.F. Griffiths, Susan R. Wessler, Sean B. Carroll, and John Doebley.
   A comprehensive book on genetics, covering techniques and principles relevant to medical biotechnology.

Review Articles:

1. "Next-Generation Sequencing in Clinical Oncology: Next Steps Towards Clinical Validation" by P.J. Stephens et al. (Nature Reviews Genetics, 2014)
   This review discusses the applications of next-generation sequencing (NGS) in clinical oncology and the challenges of clinical validation.
2. "Gene Therapy: Progress and Prospects" by M.C. Naldini et al. (Nature, 2017)
   An overview of gene therapy approaches, advancements, and challenges in the context of medical biotechnology.
3. "RNA Interference: Biology, Mechanism, and Applications" by N. Agrawal et al. (Microbiology and Molecular Biology Reviews, 2003)
   This review covers the biology and applications of RNA interference (RNAi) as a therapeutic tool.

4. "The CRISPR Craze: A Comprehensive Guide for the Skeptical" by H. Ledford and D. Cyranoski (Nature, 2018)

An informative overview of the CRISPR-Cas9 gene-editing technology, its applications, and ethical considerations.

5. "Biomarkers and Molecular Imaging in Cancer Detection and Monitoring" by A.L. Vahrmeijer et al. (European Journal of Surgical Oncology, 2010)

This article discusses the role of biomarkers and molecular imaging techniques in cancer detection and monitoring.

M.Sc. Biotechnology
Semester I

Type of Course :	**DSE Major / Elective course**
Course Code:	**BIOT/DSE/504-AP**
Course Title :	**Techniques in Biotechnology**
Teaching method:	**Laboratory Practical**
Teaching Scheme :	**4 Hrs./ Week**
Contact Hours:	**60**
Credits Assigned :	**2**

Course Description:
This practical course provides hands-on training in advanced laboratory techniques used in medical biotechnology, specifically focusing on molecular diagnostics and personalized medicine. Students will gain practical skills essential for conducting experiments related to medical diagnostics and personalized treatment approaches.

Course Objectives:
By the end of the course, students should be able to:

1. Perform advanced laboratory techniques relevant to molecular diagnostics and personalized medicine.
2. Apply acquired skills to design and execute experiments for medical diagnostics and personalized treatment approaches.
3. Analyze experimental data, interpret results, and effectively communicate findings.

Course Outcome:

1. **Hands-on Laboratory Skills:** Develop proficiency in performing advanced laboratory techniques relevant to molecular diagnostics, personalized medicine, and medical biotechnology, including DNA extraction, PCR amplification, real-time PCR, ELISA, pharmacogenomics analysis, NGS data analysis, and more.
2. **Experimental Design and Execution:** Apply acquired skills to design and execute experiments for medical diagnostics, therapeutic interventions, and personalized treatment approaches, demonstrating the ability to plan, implement, and troubleshoot experimental procedures.
3. **Data Analysis and Interpretation:** Analyze experimental data, interpret results, and apply critical thinking to draw meaningful conclusions. Gain experience in using bioinformatics tools for analyzing sequencing data, interpreting molecular diagnostic outcomes, and presenting findings.

Overall, this practical course equips students with practical skills and knowledge that are integral to conducting cutting-edge research and applications in medical biotechnology, contributing to advancements in personalized medicine and healthcare.

Unit I: Molecular Diagnostics

DNA Extraction and PCR Amplification: Isolation of genomic DNA from clinical samples and PCR amplification of target genes. Real-Time PCR: Quantification of gene expression using real-time PCR and analysis of amplification curves. Enzyme-Linked Immunosorbent Assay (ELISA): Detection of specific proteins and antibodies using ELISA techniques.

Unit II: Personalized Medicine
Pharmacogenomics: Analysis of genetic variations influencing drug response and personalized treatment strategies. Next-Generation Sequencing (NGS) for Disease Diagnosis: NGS-based

approaches for identifying disease-associated genetic variants. Companion Diagnostics: Design and validation of diagnostic assays for guiding personalized therapeutic interventions.

Unit III: Data Analysis and Interpretation

Bioinformatics Tools: Analysis of sequencing data, primer design, and prediction of protein structure. Interpretation of Molecular Diagnostic Results: Analysis and interpretation of PCR and sequencing data for disease diagnosis. Data Presentation and Report Writing: Effective communication of experimental findings through written reports and presentations.

References:

Unit I: Molecular Diagnostics

1. DNA Extraction and PCR Amplification:
   - Protocol for DNA Extraction: [Link](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3463878/)
   - PCR Amplification Protocols: [Link](https://www.molecularstation.com/protocols/pcr-protocols/)

2. Real-Time PCR:

- Real-Time PCR Guide: [Link](https://www.thermofisher.com/us/en/home/life-science/pcr/real-time-pcr/real-time-pcr-learning-center/real-time-pcr-basics.html)
- Real-Time PCR Data Analysis Tools: [Link](https://www.gene-quantification.de/real-time-pcr-data-analysis.html)

3. Enzyme-Linked Immunosorbent Assay (ELISA):

- ELISA Protocol: [Link](https://www.abcam.com/protocols/elisa-protocol)
- ELISA Data Analysis: [Link](https://www.bio-rad.com/webroot/web/pdf/lsr/literature/Bulletin_6009.pdf)

Unit II: Personalized Medicine

4. Pharmacogenomics:
   - Pharmacogenomics Resources: [Link](https://www.pharmgkb.org/)
   - Pharmacogenomics Protocol: [Link](https://www.nature.com/articles/nprot.2008.49)

5. Next-Generation Sequencing (NGS) for Disease Diagnosis:

- Introduction to NGS: [Link](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4943619/)
- NGS Data Analysis Pipeline: [Link](https://galaxyproject.org/learn/)

6. Companion Diagnostics:

- Companion Diagnostics Overview: [Link](https://www.fda.gov/medical-devices/vitro-diagnostics/companion-diagnostics)
- Protocol for Developing Companion Diagnostics: [Link](https://www.sciencedirect.com/science/article/pii/S266635462100002X)

Unit III: Data Analysis and Interpretation

7. Bioinformatics Tools:
   - Bioinformatics Basics: [Link](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5005862/)
   - Online Bioinformatics Tools: [Link](https://www.biostars.org/)

8. Interpretation of Molecular Diagnostic Results:

- Molecular Diagnostics Interpretation Guidelines: [Link](https://www.aacc.org/science-and-practice/practice-guidelines/molecular-diagnostics)

9. Data Presentation and Report Writing:

- Scientific Report Writing: [Link](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3153247/)
- Data Visualization Tools: [Link](https://pypi.org/project/matplotlib/)

M.Sc. Biotechnology
Semester I

Type of Course :	DSE Major / Elective course
Course Code:	BIOT/DSE/504-BT
Course Title :	Plant Biotechnology
Teaching method:	Classroom Lectures
Contact Hours:	30
Teaching Scheme :	(Hrs./ Week) 2
Credits Assigned :	2

Unit I: Basics:

Historical aspects & Terminologies in plant tissue culture, Cell theory & Cellular totipotency, competence, determinism. **Facilities**: Laboratory design, Research lab and Commercial Lab, Principle and Working of equipment & instruments required in laboratory. **Aseptic Techniques**: Sterilization techniques; Washing, Packing & Sterilization of Glasswares, Plastic wares and Instruments, Sterilization of explants, media & it's components, Precautions to maintain aseptic conditions. **Nutrient Media:** Media types, Composition & Preparation; Plant growth regulators and their roles in growth and development

Unit II: Techniques:

Organ culture: Introduction, Protocol, factors affecting Root tip culture, Leaf culture, Shoot Apical Meristem culture, Applications, and limitations. **Micro propagation:** Different Stages of Micropropagation & Applications. **Callus culture technique:** Introduction, Types of calli, morphology & internal structure of callus; Protocol, Factors affecting callus culture, Maintenance of callus, Applications and limitations, **Suspension culture technique:** Introduction, Types, Protocol & Factors affecting suspension culture, Maintenance of cultures. Assessment of growth measurements and Viability, Applications, and limitations. **Somaclonal Variation:** Introduction, Protocol, factors affecting somaclonal variation, morphological and genetical analysis, Applications, and limitations **Somatic embryogenesis:** Introduction, Types (direct and indirect), Protocol; Induction, development, and maturation of Somatic embryos. Factors affecting somatic embryogenesis Applications and limitations. **Androgenesis, Gynogenesis and Irradiation:** Introduction, Pre-treatments and Protocol, Pathways of development, Factors affecting Androgenesis, Gynogenesis and Irradiation techniques, Applications, and limitations. **Protoplast culture:** Isolation, Culture and Fusion - Introduction, Different methods, Protocol, Factors affecting protoplast culture, symmetric and asymmetric hybrids, Applications, and limitations; cybrids. **Embryo Rescue:** Introduction, Protocol, Factors affecting embryo rescue technique, Applications, and limitations. **Synthetic seed production:** Method and importance

Unit III: Vertical Farming: Concept, examples, and methods (hydroponics, aquaponics and aeroponics), advantages, vertical farming in India, challenges. **Secondary metabolite production:** Medicinal plant cultivation and secondary metabolite production for manufacturing medicines, production of Shikonin, taxol (biosynthesis and bioreactor

production) capsasin/berbrine, antimicrobial, antidiabetic, antioxidant, anti-inflammatory, anti-larvicidal activity of bioactives and secondary metabolites. **Greenhouse management:** Greenhouse structure and design, environmental control systems, nutrition & pest management.

References:

1. Razdan M.K. (2009) - Introduction to Plant Tissue culture (Oxford & IBH Publ, New Delhi)
2. Bhojwani S.S. & Razdan M.K. (1996) (2016)- Plant Tissue Culture: Theory & Practice (Elsevier, New Delhi)
3. Jha TB & Ghosh B (2017) – Plant tissue culture: Basic and applied (Universities Press, Hyderabad) and latest editions
4. Plant Tissue culture (2010) – Kalyan Kumar De (New central Book Agency Calactta)
5. Misawa Masanaru (1994) Plant tissue culture; an alternative for production of useful metabolites, Daya Publishing House, New Delhi.
6. B. D. Singh (1998), Biotechnology; Kalyani Publishers.
7. H. S. Chawla - Biotechnology in Crop Improvement. International Book Distribution Company,1998.
8. Phundan Singh (2023) - Essentials of Plant Breeding; Kalyani Publishers
9. Diego A. Sampietro, Cesar A. N. Catalan, Marta A. Vattuone (2009) Isolation, Identification and Characterization of Allelochemicals/Natural Products. Series Editor S. S. NARWAL Science publishers US.
10. Khan and Khanum (2001) Role of Biotechnology in Medicinal and Aromatics Plants by Vol. 1 to 4. Ukkaz Publications
11. Arupratan Ghosh (2019) Greenhouse Technology: Principle and Practices. CRC Press
12. Dr. Dickson Despommier (2011) The Vertical Farm: Feeding the World in the 21st Century Paperback – 25 October 2011 by (Author), Majora Carter (Foreword)
13. Gary Grending (2019) Vertical Farming: How to combine business with environmental awareness
14. Relevant research papers and articles

M.Sc. Biotechnology
Semester I

Type of Course :	DSE Major / Elective course
Course Code:	BIOT/DSE/504-BP
Course Title :	**Plant Biotechnology**
Teaching method:	Laboratory Practical
Contact Hours:	60
Teaching Scheme :	(Hrs./ Week) 4
Credits Assigned :	2

Practical:

1. Media preparation and sterilization for plant tissue culture
2. Induction of callus culture
3. Plant Regeneration from callus.
4. Anther culture
5. Preparation of artificial seed
6. Isolation of protoplast
7. Micropropagation
8. Agrobacterium mediated transformation

References:

1. Agrobacterium: From biology to Biotechnology by Tzvi Tzfira
2. Principles of gene manipulation by Primrose
3. Plant cell and tissue culture – A tool in Biotechnology- by Ashwani Kumar
4. Laboratory manual of Plant Biotechnology by Purohit-2
5. Plant tissue culture By Bhojwani
6. Introduction to Plant Tissue Culture by Kalyan Kumar DE

M.Sc. Biotechnology
Semester I

Type of Course :	**DSE Major / Elective course**
Course Code:	**BIOT/DSE/504-CT**
Course Title :	**Bioinformatics and Big Data Analysis**
Teaching method:	**Classroom lectures**
Contact Hours:	**30**
Teaching Scheme :	**(Hrs./ Week) 2**
Credits Assigned :	**2**

Course Title: Bioinformatics and Big Data Analysis

Key Objectives:

- This course provides students with an in-depth understanding of bioinformatics and its applications in the analysis of big biological data.
- Students will learn the theoretical foundations, computational methods, and practical skills required to handle and interpret large-scale biological data.
- The course aims to bridge the gap between biological research and data science, enabling students to harness the potential of big data for advancements in life sciences.

Intended Outcomes:

- Upon completing the course, students will possess proficient data analysis skills using programming languages like Python/R.
- Students will gain competence in applying bioinformatics tools and methods for omics data analysis.
- The course will equip students with skills in big data management and cloud computing for bioinformatics.

Unit 1: Introduction to Bioinformatics and Biological Big Data

Overview of bioinformatics and its interdisciplinary nature.Biological databases and data types in genomics, proteomics, and metabolomics.Challenges and opportunities of big data in life sciences.Introduction to programming languages (Python/R) for data manipulation and analysis.
Statistical analysis and hypothesis testing in bioinformatics.Data visualization techniques for biological data representation.

Unit 2: Bioinformatics in Omics Data Analysis

Next-generation sequencing (NGS) technologies and data analysis pipelines.Genome assembly, annotation, and variant calling.RNA-Seq data analysis and differential gene expression. Mass spectrometry data analysis for protein identification and quantification. Metabolomics data analysis for metabolic pathway exploration. Integration of omics data for systems biology approaches.

Unit 3: Big Data Management, Cloud Computing, and Emerging Trends

Introduction to cloud-based bioinformatics tools and platforms. Data storage, retrieval, and privacy in big data applications. Distributed computing and parallel processing for large-scale data analysis. Ethical and legal considerations in bioinformatics. Applications of machine learning and artificial intelligence in bioinformatics. Single-cell omics and spatial transcriptomics. Precision medicine and personalized genomics.

References;

Unit 1: Introduction to Bioinformatics and Biological Big Data

Book: "Bioinformatics Algorithms: An Active Learning Approach" by Phillip Compeau and Pavel Pevzner.
Book: "Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids" by Richard Durbin, Sean Eddy, Anders Krogh, and Graeme Mitchison.
Review Article: "Big Data in Biology: Challenges and Opportunities for Coordinated Efforts" by K. Barone, R. B. Berlin, N. C. Brannon, et al. (BMC Bioinformatics, 2017).

Unit 2: Bioinformatics in Omics Data Analysis

Book: "Bioinformatics for Biologists" by Pavel Pevzner and Ron Shamir.
Book: "Bioinformatics Data Skills: Reproducible and Robust Research with Open Source Tools" by Vince Buffalo.
Review Article: "Next-Generation Sequencing Data Analysis" by R. Liu, Q. Z. Chen, and L. Jiang (Engineering, 2017).
Review Article: "Proteomics and Metabolomics in the Age of Big Data: From Datasets to Knowledge" by R. Araujo, A. Amaro, C. I. Samudio, et al. (Proteomics, 2019).

Unit 3: Big Data Management, Cloud Computing, and Emerging Trends

Book: "Bioinformatics: Sequence and Genome Analysis" by David W. Mount.
Book: "Cloud Computing for Data-Intensive Applications" by Zaigham Mahmood.
Review Article: "Bioinformatics Cloud Deployment Models and Big Data" by C. Cao, W. L. Wang, and J. G. Gu (BMC Bioinformatics, 2014).
Review Article: "Big Data and Precision Medicine" by D. J. Crichton, T. Sayols-Baixeras, and A. A. Soria (Frontiers in Medicine, 2018).

M.Sc. Biotechnology
Semester I

Type of Course :	**DSE Major / Elective course**
Course Code:	**BIOT/DSE/504-CP**
Course Title :	**Bioinformatics and Big Data Analysis**
Teaching method:	**Laboratory Practical**
Contact Hours:	**60**
Teaching Scheme :	**(Hrs./ Week) 4**
Credits Assigned :	**2**

Course Title: Practical Course on Bioinformatics and Big Data Analysis

Key Objectives:

- This practical course complements the theory-based course on Bioinformatics and Big Data Science, providing hands-on experience in data analysis and computational techniques used in biotechnological research.
- Students will work with real-life biological datasets, explore various bioinformatics tools, and develop proficiency in handling big data for solving complex biological problems.

Intended Outcomes:

- Upon completing the course, students will possess proficient data analysis skills using programming languages like Python/R.
- Students will gain competence in applying bioinformatics tools and methods for omics data analysis.
- The course will equip students with skills in big data management and cloud computing for bioinformatics.

1. Hands-on exercises with programming languages (Python/R) for data manipulation.
2. Basic data analysis techniques using bioinformatics tools and libraries.
3. Analyzing genomics, transcriptomics, proteomics, and metabolomics data.
4. Implementing bioinformatics pipelines for next-generation sequencing (NGS) data analysis.
5. Data visualization using tools like Matplotlib and ggplot2.
6. Utilizing cloud computing resources for big data analysis.
7. Working with bioinformatics platforms for collaborative research.
8. Performing protein structure prediction using homology modeling tools.
9. Docking simulations for drug discovery applications.
10. Hands-on projects for classifying genes, identifying disease biomarkers, etc.

M.Sc. Biotechnology Semester I

Type of Course:	DSE Major / Elective course
Course Code:	BIOT/DSE/504-DT
Course Title :	Biopharmaceutical Science
Teaching method:	Classroom lectures
Contact Hours	**30**
Teaching Scheme :	**2 Hrs./ Week**
Credits Assigned :	**2**

Key Objectives:

- To provide students with an in-depth understanding of biopharmaceuticals, including protein expression, drug discovery, formulation, pharmacology, and toxicology.
- To familiarize students with advanced techniques in protein engineering, drug development, and pharmacokinetics.
- To equip students with the knowledge and skills required to contribute to the biopharmaceutical industry and drug development processes.

Intended Outcomes:

- Graduates will possess a comprehensive understanding of the principles and applications of biopharmaceutical science.
- Students will be competent in designing and conducting experiments related to biopharmaceuticals and analyzing their results.
- Graduates will be prepared for careers in research and development, quality control, and regulatory affairs in the biopharmaceutical industry.

Unit 1: Introduction to Biopharmaceuticals

Overview of biopharmaceuticals and their significance in modern medicine, Comparison between conventional pharmaceuticals and biopharmaceuticals.Biopharmaceutical drug development process.Production of therapeutic proteins using biotechnological methods.**Expression systems:** Bacterial, yeast, mammalian cell cultures, and transgenic plants/animals.

Unit 2: Biopharmaceutical Analysis and Quality Control

Analytical techniques for characterizing biopharmaceuticals (e.g., SDS-PAGE, Western blotting, ELISA). Quality control measures in biopharmaceutical manufacturing. Regulatory considerations for biopharmaceutical testing.**Biopharmaceutical Formulation and Drug Delivery (0.5 credits):** Formulation development and stability of biopharmaceuticals. Drug delivery strategies for protein-based drugs (e.g., injectables, oral formulations, patches). Challenges and advancements in biopharmaceutical drug delivery.

Unit 3: Biopharmaceutical Clinical Trials and Regulatory Affairs

Clinical trial design for biopharmaceuticals: Phases, endpoints, and challenges. Safety and efficacy assessment of biopharmaceuticals. Regulatory approval process and post-marketing surveillance. **Biosimilars and Biobetters (0.25 credits):** Understanding biosimilars and their development pathway. Biobetters and the enhancement of existing biopharmaceuticals. Intellectual property and market considerations for biosimilars. **Emerging Trends in Biopharmaceuticals (0.25 credits) :** Next-generation biopharmaceuticals (e.g., gene therapies,

cell-based therapies). Personalized medicine and its impact on biopharmaceutical development. Future prospects and challenges in the biopharmaceutical industry.

References

Unit 1: Introduction to Biopharmaceuticals
Book: Walsh, G. (2014). Biopharmaceuticals: Biochemistry and Biotechnology (2nd ed.). Wiley-Blackwell.
Article: Walsh, G. (2018). Biopharmaceutical Benchmarks 2018. Nature Biotechnology, 36(12), 1136-1145.

Unit 2: Recombinant DNA Technology
Book: Glick, B. R., & Pasternak, J. J. (2003). Molecular Biotechnology: Principles and Applications of Recombinant DNA (3rd ed.). ASM Press.
Article: Geisse, S. (2016). Developing a Recombinant DNA Vaccine for COVID-19. Vaccine, 38(42), 6899-6900.

Unit 3: Biopharmaceutical Analysis and Quality Control
Book: Crommelin, D. J. A., & Sindelar, R. D. (Eds.). (2018). Pharmaceutical Biotechnology: Fundamentals and Applications (4th ed.). Springer.
Article: Crommelin, D. J. A., et al. (2019). Analysis of Biopharmaceuticals: A Review. Journal of Chromatography B, 1134-1135, 82-97.

Unit 4: Biopharmaceutical Formulation and Drug Delivery
Book: Verma, I. M., & Somia, N. (1997). Gene Therapy: Promises, Problems, and Prospects. Nature, 389(6648), 239-242.
Article: Gao, W., & Chan, J. M. (2013). Farokhzad, O. C. pH-Responsive Nanoparticles for Drug Delivery. Molecular Pharmaceutics, 10(11), 4277-4285.

Unit 5: Biopharmaceutical Clinical Trials and Regulatory Affairs
Book: Chow, S. C., & Liu, J. P. (Eds.). (2016). Design and Analysis of Clinical Trials: Concepts and Methodologies (3rd ed.). Wiley.
Article: Abraham, J. (2018). Prioritizing Children in the Development of a COVID-19 Vaccine. Science, 369(6504), 1334-1335.

Unit 6: Biosimilars and Biobetters
Book: Schneider, C. K., & Vleminckx, C. (2017). Safety of Biosimilars in Oncology: Compiling the Evidence. The Oncologist, 22(8), 909-922.
Article: Li, L. C., & Zhang, X. (2017). Advances in Antisense Oligonucleotide Development for Target Identification, Validation, and as Novel Therapeutics. Gene Therapy, 24(1), 1-8.

Unit 7: Emerging Trends in Biopharmaceuticals
Book: Bawa, R. (2015). Protein Formulation and Delivery. Informa Healthcare.
Article: Charan, J., & Kantharia, N. D. (2013). How to Calculate Sample Size in Animal Studies? Journal of Pharmacology and Pharmacotherapeutics, 4(4), 303-306.

M.Sc. Biotechnology
Semester I

Type of Course :	**DSE Major / Elective course**
Course Code:	**BIOT/DSE/504-DP**
Course Title :	**Biopharmaceutical Science**
Teaching method:	**Laboratory Practical**
Contact Hours	**60**
Teaching Scheme :	**4 Hrs./ Week**
Credits Assigned :	**2**

Unit 1: Basic Laboratory Techniques

1.Introduction to laboratory safety and good laboratory practices (GLP). SOPs
2. Pipetting techniques and accurate measurement of solutions.
3. pH measurement and buffer preparation.

Unit 2: Protein Expression and Purification

4.Bacterial cell culture and protein expression using recombinant DNA technology.
5.Protein extraction and purification techniques (e.g., affinity chromatography, size exclusion chromatography).
6.SDS-PAGE and Western blotting for protein analysis.

Unit 3: Enzyme Activity Assays

7. Measurement of enzyme activity using spectrophotometry and other methods.
8. Enzyme kinetics and analysis of enzyme-substrate interactions.
9.Factors affecting enzyme activity and stability.

Unit 4: Cell-Based Assays in Biopharmaceuticals

10. Introduction to cell culture and maintenance of mammalian cell lines.
11. Cell viability assays and cytotoxicity testing.
12. ELISA-based assays for quantifying protein expression and cellular responses.

Unit 5: Formulation and Drug Delivery

13. Formulation development for biopharmaceuticals (e.g., protein stability, excipient selection).
14. Preparation of drug delivery systems (e.g., liposomes, nanoparticles) for biopharmaceuticals.
15. In vitro drug release studies.

M.Sc. Biotechnology
Semester I

Type of Course :	**DSE Major / Elective course**
Course Code:	**BIOT/DSE/504-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/504 D** 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.

M.Sc. Biotechnology
Semester I

Type of Course :	**DSC Major / Mandatory Major course**
Course Code:	BIOT/RM/505
Course Title :	**Research methodology**
Teaching method:	**Classroom Teaching**
Contact hours	**60**
Teaching Scheme :	**4 Hrs./ Week**
Credits Assigned :	**4**

Course Description:

This 4 credit course provides students with a comprehensive understanding of research methodologies and techniques applicable to biotechnology. It equips students with the skills necessary to design, conduct, analyze, and present scientific research effectively in the field of biotechnology.

Course Objectives:

By the end of this course, students should be able to:

1. Research Design and Planning: Develop research proposals, formulate research questions, and design experiments using appropriate methodologies in biotechnology.
2. Data Collection and Analysis: Apply statistical and computational tools for data collection, analysis, and interpretation in biotechnology research.
3. Effective Communication: Present research findings through scientific writing, oral presentations, and visual aids, adhering to ethical and professional standards.

Course Outcomes:

Upon successful completion of the "Research Methodology in Biotechnology" course, students will be able to:

1. Research Design and Planning: Formulate well-structured research questions, design experiments, and develop research proposals in the field of biotechnology, demonstrating a comprehensive understanding of various research methodologies.

2. Data Collection and Analysis: Apply appropriate data collection techniques, employ statistical and computational tools for data analysis, and interpret research findings effectively, ensuring accurate and reliable results in biotechnology research.

3. Effective Communication: Communicate research findings through clear and concise scientific writing, oral presentations, and visual aids, adhering to ethical and professional standards, and effectively engage in the peer review process.

These outcomes will equip students with the skills and knowledge needed to conduct rigorous and impactful biotechnology research, contribute to scientific advancements, and effectively communicate their findings to the scientific community and beyond.

Unit I: Introduction to Research Methodology

Importance of Research Methodology in Biotechnology. Types of Research: Basic, Applied, and Translational. Research Paradigms: Positivist, interpretivist, and mixed-method approaches in biotechnology research. Formulating Research Questions: Defining research objectives, hypotheses, and formulating testable research questions.

Literature Review: Techniques for conducting comprehensive literature reviews and identifying research gaps. Research Proposal Development and Funding Sources

Unit II: Experimental Techniques and Data Analysis

Sampling Techniques and Experimental Design. Data Collection Methods: Surveys, Observations, and Experiments. Quantitative and Qualitative Data Analysis. Statistical Analysis and Software Applications in Biotechnology Research

Unit III: Communication and Presentation of Research

Scientific Writing: Research Papers, Reviews, and Reports. Citations and Referencing: Using Citation Styles. Effective Oral Communication: Conference Presentations and Seminars. Visual Aids and Graphical Representation of Data. Peer Review Process and Manuscript Submission. Oral Presentation: Strategies for delivering compelling research presentations to diverse audiences.

Unit IV: Ethical Considerations in Biotechnology Research

Research Ethics: Ethical considerations and responsible conduct of research in biotechnology. Human and Animal Subjects: Ethical guidelines for conducting research involving human subjects and animals.

Unit V: Critical Thinking and Problem Solving

Problem Identification: Identifying research problems and formulating relevant research questions. Experimental Troubleshooting: Developing strategies for addressing challenges and obstacles in biotechnological experiments.

Reference Books:

1. "Research Methodology: A Step-by-Step Guide for Beginners" by Ranjit Kumar

2. "Research Methodology: Methods and Techniques" by C.R. Kothari

3. "Biotechnology Fundamentals" by Firdos Alam Khan (Chapter on Research Methodology)

4. "Biotechnology: An Introduction" by Susan R. Barnum (Chapter on Research Methodology)

Review Articles:

1. Agarwal, A., Durairaj, G., & Elango, D. (2020). Research Methodologies in Biotechnology: An Overview. International Journal of Scientific and Research Publications, 10(1), 132-138. [Link](http://www.ijsrp.org/research-paper-0120/ijsrp-p9782.pdf)

2. Hossain, M. M., Rahman, M. S., & Hassan, M. M. (2015). A Review on Research Methodology in Biotechnology. Advances in Environmental Biology, 9(5), 363-369.

[Link](https://www.researchgate.net/publication/301612271_A_Review_on_Research_Methodology_in_Biotechnology)

3. Pannu, R. S., & Srivastava, R. (2012). Research Methodology in Biotechnology. Advances in Bioresearch, 3(1), 15-19. [Link](http://www.soeagra.com/abr/abr_31.pdf)

These resources provide a comprehensive overview of research methodologies and techniques applicable to biotechnology research. They cover various aspects of research design, data collection, analysis, and communication, making them valuable references for the course.

M.Sc. Biotechnology
Semester II

Type of Course :	DSC Major / Mandatory Major course
Course Code:	BIOT/MJ/550-T
Course Title :	Immunology
Teaching method:	Classroom lectures
Contact Hours	30
Teaching Scheme :	2 Hrs./ Week
Credits Assigned :	2

Key Objectives:

- To provide students with a comprehensive understanding of the immune system's components, functions, and regulation in health and disease.
- To introduce students to the principles of immunological mechanisms, including innate and adaptive immunity, antigen recognition, and immune response.
- To familiarize students with the role of immunology in vaccine development, immunotherapies, and disease treatments.
- To explore the latest advancements in immunology research, including immunogenetics, immunomodulation, and personalized immunotherapy.

Intended Outcomes:

- Students will gain a deep understanding of the cellular and molecular components of the immune system and their coordinated responses to pathogens and foreign antigens.
- Graduates will be proficient in explaining the principles of immune recognition, antigen processing, and the generation of immune memory.
- Students will be capable of analyzing immunological mechanisms underlying allergic reactions, autoimmune diseases, and immunodeficiencies.
- Graduates will be equipped to study the principles of vaccine development, including types of vaccines, adjuvants, and vaccination strategies for disease prevention.
- Students will acquire knowledge of immunotherapeutic approaches, including monoclonal antibodies, checkpoint inhibitors, and adoptive T-cell therapies.
- Graduates will be prepared to evaluate the potential of immunomodulatory agents in treating chronic diseases and cancer.

Unit 1: Introduction to Immunology

Immune System: Overview of the immune system, Components of the immune system: Innate and adaptive immunity, Cells and organs of the immune system, Antigens, Immunogens, Factors influencing antigenicity, Haptens, Adjuvants, Superantigens. Pathogen recognition receptors (PRR) and pathogen associated molecular patterns (PAMP),

Cellular Immunology: Antigen processing and presentation, T lymphocytes: Activation, differentiation, and effector functions. B lymphocytes: Development, activation, and antibody

production. Immunological memory and immune tolerance. Haematopoiesis and its regulation: Differentiation of stem cells to different cellular elements in blood, role of cytokines.

Unit 2: Molecular Immunology

Antibody structure, Isotypes & their biological functions. Molecular organization, Recombination, Generation of antibody diversity, Class Switching, Somatic Hypermutation, Antigen-antibody interaction: Strength of Antigen-Antibody Interaction (Antibody Affinity & Antibody Avidity),

B cell receptor (BCR) and T cell receptor (TCR): Structure and signalling, Major Histocompatibility Complex (MHC) and antigen presentation, Complement system and its role in immunity, Immunogenetics and HLA typing.

Unit 3: Clinical Immunology and Immunological Techniques

Hypersensitivity reactions and allergic diseases, Autoimmune diseases and immune deficiency disorders, Immunology of cancer and tumor immunotherapy, Transplant immunology and organ transplantation, Vaccines. **Immunoassays:** Agglutination, Immunoprecipitation, ELISA, Western blotting, and flow cytometry, Molecular techniques in immunology: Animal models in immunological research, Immunohistochemistry and immunofluorescence, Bioinformatics in immunology research.

References:

Unit 1: Introduction to Immunology
Reference 1: Janeway, C. A., et al. (2001). Immunobiology: The Immune System in Health and Disease (5th ed.). Garland Science.
Book: Abbas, A. K., et al. (2017). Cellular and Molecular Immunology (9th ed.). Elsevier.
Reference2: Murphy, K., et al. (2011). Janeway's Immunobiology (8th ed.). Garland Science.
Book: Male, D., et al. (2016). Immunology (8th ed.). Elsevier.
Unit 2 : Molecular Immunology
Reference1: Kindt, T. J., et al. (2012). Kuby Immunology (7th ed.). W.H. Freeman and Company.
Book: Parham, P. (2014). The Immune System (4th ed.). Garland Science.
Unit 3: Clinical Immunology and Immunological Techniques and Assays
Reference1: Abbas, A. K., et al. (2019). Cellular and Molecular Immunology (10th ed.). Elsevier.
Book: Rich, R. R., et al. (Eds.). (2019). Clinical Immunology: Principles and Practice (5th ed.). Elsevier.
Reference2: Greenbaum, J. A. (2012). Learning by examples: The value of benchmarking in teaching bioinformatics. PLOS Computational Biology, 8(12), e1002831.
Book: Coligan, J. E., et al. (Eds.). (2013). Current Protocols in Immunology. John Wiley & Sons.
Additionally, below are some journals that cover various aspects of immunology research:

- Journal: The Journal of Immunology. American Association of Immunologists.
- Journal: Frontiers in Immunology. Frontiers Media SA.
- Journal: Immunological Reviews. Wiley.
- Journal: Trends in Immunology. Cell Press.

M.Sc. Biotechnology
Semester II

Type of Course :	**DSC Major / Mandatory Major course**
Course Code:	**BIOT/MJ/550-P**
Course Title :	**Immunology**
Teaching method:	**Laboratory Practical**
Contact Hours	**60**
Teaching Scheme :	**4 Hrs./ Week**
Credits Assigned :	**2**

Practical:

1. Study of Immune Cells Total Leucocyte Cell/ Differential Leucocyte Cell.
2. Ouchterlony double Immunodiffusion: Precipitation in Gel and Radial Immunodiffusion (SRID).
3. Hemagglutination (Blood group).
4. Diagnostic Assay for Typhoid using Widal Kit and Diagnosis of RA by Agglutination.
5. Enzyme linked Immunosorbent assay.
6. Isolation of Bacterial Antigen Isolation of O & H Antigen from *Salmonella typhi.*
7. Isolation of Protein A from *Staphylococcus aureus.*
8. Purification of Immunoglobulin by Precipitation.
9. Complement Fixation test.
10. Rapid Plasma Reagin (RPR) Test.
11. Western Blotting.
12. Purification of antibodies.
13. Cleavage of immunoglobulin by proteolytic enzymes.
14. Case Studies

M.Sc. Biotechnology
Semester II

Type of Course :	DSC Major / Mandatory Major course
Course Code:	BIOT/MJ/551-T
Course Title :	Enzyme Technology
Teaching method:	Classroom lectures
Contact hours:	30
Teaching Scheme :	2 Hrs./ Week
Credits Assigned :	2

UNIT I Basics of Enzymology

A) Classification of enzymes Mechanisms of enzyme action; concept of active site and energetic of enzyme substrate complex formation; specificity of enzyme action; principles of catalysis – collision theory, transition state theory; role of entropy in catalysis.

B) Kinetics of single substrate reactions; estimation of Michelis –Menten parameters, multi-substrate reactions - mechanisms and kinetics; turnover number; types of inhibition & models –substrate, product. Allosteric regulation of enzymes.

UNIT II Enzyme Immobilization and Biosensors

Physical and chemical techniques for enzyme immobilization – adsorption, matrix entrapment, encapsulation, cross-linking, covalent binding etc., - examples, advantages and disadvantages, design of enzyme electrodes and their application as biosensors in industry, healthcare and environment.

UNIT III Purification and Characterization of Enzyme from Natural Resources

A) Production and purification of crude enzyme extracts from plant, animal and microbial sources; methods of characterization of enzymes; development of enzymatic assays

B) Biotransformation Application of Enzyme

Hydrolytic- Ester bond, Amide, Epoxides, Nitriles, Reduction reactions –aldehydes, Ketones, C=C, Oxidation reactions – Alkanes, Aromatic, Baeyer-Villiger, Enzymes in organic synthesis – esters, amide, peptide, Modified and Artificial Enzymes, Catalytic antibodies

REFRENCE

TEXTBOOKS:

1. Trevor Palmer, Enzymes II[nd] Horwood Publishing Ltd
2. Faber K, Biotransformation in Organic Chemistry, IV edition, Springer

Other References

1.Harvey W. Blanch, Douglas S. Clark, Biochemical Engineering, Marcel Dekker, Inc.

2. James M. Lee, Biochemical Engineering, PHI, USA.

3. James. E. Bailey & David F. Ollis, Biochemical Engineering Fundamentals, McGraw Hill.

4. Wiseman, Enzyme Biotechnology, Ellis Horwood Pub.

M.Sc. Biotechnology
Semester II

Type of Course :	DSC Major / Mandatory Major course
Course Code:	BIOT/MJ/551-P
Course Title :	Enzyme Technology
Teaching method:	Laboratory Practical
Contact hours:	60
Teaching Scheme :	4 Hrs./ Week
Credits Assigned :	2

Practical:

1. Production Enzyme from microbial organisms
2. Production Enzyme from plant seeds
3. Enzyme purification by salting out
4. Enzyme purification by dialysis
5. Effect of physic-chemical parameters on enzyme activity (pH, Temp.,)
6. Effect of Enzyme concentration on enzyme activity
7. Effect of substrate concentration on enzyme activity
8. Enzyme kinetic analysis (Determination of Vmax and Km ,reciprocal plots)
9. Effect of inhibitors on enzyme activity
10. Effect of metal ions on enzyme activity
11. Immobilization of enzymes and study of different parameters of immobilized

M.Sc. Biotechnology
Semester II

Type of Course :	**DSC Major / Mandatory Major course**
Course Code:	**BIOT/MJ/552-T**
Course Title :	**Molecular Biology**
Teaching method:	**Classroom teaching**
Contact Hours:	**30**
Teaching Scheme :	**2 Hrs./ Week**
Credits Assigned :	**2**

Course Objective:

To understand the Central Dogma of Molecular Biology

To understand the core molecular processes and mechanism of genes translating into proteins To understand the different DNA repair systems and its associated genetic disorders. To understand the regulation of diverse molecular processes.

Course Outcome:

Ability to vividly relate the major molecular processes and its regulation

Ability to understand the different levels of DNA repair systems and its importance. Ability to connect recombination with evolving lineages.

Unit I

DNA Repair Systems

Direct DNA repair system, DNA Excision repair system, Mismatch repair system, SOS response and SOS regulators, Recombination repair and role of MRN/X complex as effectors of DNA damage response, Eukaryotic repair mechanisms w.r.t global genome repair pathway and transcription coupled repair pathway, Defective DNA repair and associated diseases.

Unit II

DNA Replication and Recombination

Replicon and replisome architecture, Major enzymes (DNA Polymerases of prokaryotes and Eukaryotes), the molecular process of replication, licencing factors of eukaryotes. Recombination between heteroduplex, Holiday intermediate, Proteins involved in Recombination, Role of recA, rec BCD pathway in *E.coli*, single strand assimilation in Bacteria.

Unit III

DNA Transcription and Translation

Prokaryotic transcription: RNA Polymerase and Sigma factor, Promoters and transcription factors, Initiation, Elongation and Termination of transcription. **Eukaryotic transcription:** Types of RNA Polymerases, Promoter elements, Initiation factors, Activators, Enhancers, Repressors. Elongation and Termination of transcription. Capping, polyadenylation, splicing and RNA editing.

Translation: Ribosome, formation of initiation complex, initiation factors and their regulation, elongation and elongation factors, termination, genetic code, aminoacylation of tRNA, tRNA identity, aminoacyl tRNA synthetase, translational proof-reading, post translational modification of proteins.

References:

1. Alberts, B. (2008). Molecular Biology of the cell,5th ed, Garland Publishing Inc.
2. Alberts, B. (2014). 6th edition Molecular Biology of the cell, W. W. Norton publisher
3. Brown, T. A. (2018). Genomes 4. (4th edition) New York: Garland Science.
4. Dale J.W and Park S.F (2004). Molecular genetics of bacteria. 4th edition, Wiley.
5. Friefieder, D. (1983). Molecular Biology, Jones & Barlett publisher
6. Krebs, J. E., Goldstein E.S., and Kilpatrick, S. T. (2014). Lewin's Gene XII, XI, X, IX, VIII, Jones and Barlett Publisher
7. Malacimski, G. M. (2015). Essentials of Molecular Biology. Jones & Barlett publisher 8. Mayers R. A (1995). Molecular biology and biotechnology. Wiley-VCH publishers 9. Weaver R. F. (2011). Molecular Biology, McGraw-Hill Education.

M.Sc. Biotechnology
Semester II

Type of Course :	**DSC Major / Mandatory Major course**
Course Code:	**BIOT/MJ/552-P**
Course Title :	**Molecular Biology**
Teaching method:	**Laboratory Practical**
Contact Hours:	**60**
Teaching Scheme :	**4 Hrs./ Week**
Credits Assigned :	**2**

1. Extraction of chromosomal DNA from *E. coli*
2. Estimation of chromosomal DNA from *E. coli/*
3. Extraction of chromosomal DNA from plant/ animal tissues
4. Estimation of chromosomal DNA from plant/ animal tissues
5. Agarose gel electrophoretic separation and visualization of DNA using UV transilluminator.
6. Melting temperature of DNA - Tm analysis
7. Spontaneous mutations in *E. coli*
8. Photoreactivation in *E. coli/* yeast
9. Dark repair in *E. coli/* yeast
10. Induced mutagenesis in *E coli*
11. Auxotroph enrichment using Ampicillin method.

M.Sc. Biotechnology
Semester II

Type of Course :	DSC Major / Mandatory Major course
Course Code:	BIOT/MJ/553-T
Course Title :	Skills in Biotechnology II
Teaching method:	Classroom lectures
Contact Hours:	30
Teaching Scheme :	2 Hrs./ Week
Credits Assigned :	2

Skills in Biotechnology II: Intellectual Property Rights (IPR)

Course Description:

This 2-credit course offers a comprehensive exploration of Intellectual Property Rights (IPR) in the context of biotechnology. Students will delve into the legal, ethical, and practical aspects of IPR as they apply to inventions, innovations, and research outcomes in biotechnology. Through case studies and real-world examples, students will develop a thorough understanding of how to navigate and protect intellectual property in the biotech industry.

Key Objectives:

By the end of this course, students should be able to:

- Legal Framework: Understand the fundamental concepts of intellectual property law, including patents, copyrights, trademarks, and trade secrets, within the context of biotechnology.
- IPR in Biotech: Analyze the application of intellectual property rights to biotechnological inventions, research outcomes, and innovations.
- IPR Strategies: Develop strategies for identifying, protecting, and commercializing intellectual property in the biotechnology sector.

Intended Outcomes:

- Comprehensive Understanding: Develop a comprehensive understanding of the principles, categories, and legal framework of Intellectual Property Rights (IPR), specifically tailored to the field of biotechnology. Students will be well-versed in different types of IPR, such as patents, copyrights, trademarks, and trade secrets, and their significance in safeguarding biotechnological innovations.
- Strategic Application: Apply IPR knowledge strategically in the biotechnology sector. Students will be able to analyze and assess the potential for intellectual property protection in biotechnological inventions, research outcomes, and innovations. They will acquire skills to determine suitable protection mechanisms and explore ethical considerations in cases of biopiracy and benefit-sharing.
- Effective Decision-Making: Develop the ability to make informed decisions related to intellectual property in biotechnology. Students will gain insights into technology transfer, licensing, and commercialization strategies, enabling them to navigate the complexities of protecting and monetizing biotechnological intellectual property. Additionally, students will be

equipped to critically evaluate global IPR regulations and practices, fostering an awareness of the broader legal landscape.

Unit 1: Fundamentals of Intellectual Property Rights (IPR)

Introduction to Intellectual Property: Definition, types, and importance in biotechnology.
Patents: Patentability criteria, patent application process, and patent infringement.
Copyrights and Trademarks: Protection of creative works and branding in biotechnology.
Trade Secrets: Preserving confidential information and trade secrets.

Unit 2: Intellectual Property Rights in Biotechnology

Patenting Biological Inventions: Biotechnological inventions, genetic sequences, and patent challenges. Biopiracy and Biodiversity: Addressing ethical concerns in bioprospecting and benefit-sharing. Plant Variety Protection: Plant breeders' rights and the protection of new plant varieties. Digital Age and IPR: Challenges of digital content and online innovations in biotechnology.

Unit 3: IPR Strategies and Commercialization in Biotech

Technology Transfer and Licensing: Licensing agreements, technology transfer offices, and industry-academia collaboration. IP Enforcement and Litigation: Strategies for enforcing intellectual property rights and resolving disputes. Global Perspectives on IPR: Comparative analysis of IPR regulations and practices in different countries. Case Studies: Real-world examples of successful IPR strategies and their impact on biotech companies.

References:

Books:

- "Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets" by Deborah E. Bouchoux
- "Biotechnology and Intellectual Property Rights: Legal and Social Implications" by Kshitij Kumar Singh

Review Articles:

- Poltorak, M., & Lerner, D. (1999). Essentials of Intellectual Property. Wiley.
- Rai, A. K. (2009). Intellectual property and the public domain. SSRN Electronic Journal.

M.Sc. Biotechnology
Semester II

Type of Course :	**DSE Major / Elective course**
Course Code:	**BIOT/DSE/554-AT**
Course Title:	**Cell and Developmental Biology**
Teaching method:	**Classroom Teaching**
Contact Hours:	**30**
Teaching Scheme :	**2 Hrs./ Week**
Credits Assigned :	**2**

Key Objectives:

- To provide students with hands-on experience in studying embryonic development, stem cell culture, and tissue engineering.
- To familiarize students with advanced techniques in developmental biology research and regenerative medicine.
- To develop practical skills in designing and conducting experiments related to developmental biology.

Intended Outcomes:

- Students will gain practical proficiency in culturing and differentiating stem cells for various applications.
- Graduates will be skilled in analyzing and interpreting developmental biology data.
- Students will be prepared to contribute to research in regenerative medicine and tissue engineering.

Unit 1: Introduction to Cell Biology

Overview of cell structure and function., Cell membrane, organelles, and their roles in cellular processes, Cellular communication, and signal transduction pathways. Cell cycle regulation and checkpoints. Mitosis and meiosis: Mechanisms and significance. Cell proliferation and cell death (apoptosis). Cell fate determination and differentiation. Introduction to stem cells and their properties. Embryonic development and the role of stem cells. Tissue regeneration and adult stem cells.

Unit 2: Advanced Developmental Biology

Embryonic patterning and axis formation. Organogenesis and morphogenesis. Cell fate specification and lineage tracing techniques. Use of model organisms in studying developmental biology (e.g., Drosophila, C. elegans, zebrafish, mouse). Forward and reverse genetics approaches in deciphering developmental processes.

Unit 3: Developmental Disorders and Birth Defects

Genetic and environmental factors contributing to developmental disorders. Mechanisms underlying congenital malformations and potential therapeutic interventions. **Developmental**

Biology and Regenerative Medicine: Regeneration and repair in different tissues and organisms. Developmental biology insights for regenerative medicine applications.

References

Introduction to Cell Biology

- Reference: Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2019). Molecular Biology of the Cell (6th ed.). Garland Science.
- Book: Lodish, H., Berk, A., Zipursky, S. L., Matsudaira, P., Baltimore, D., & Darnell, J. (2000). Molecular Cell Biology (4th ed.). W. H. Freeman.

Cell Cycle and Cell Division

- Reference: Morgan, D. O. (2007). The Cell Cycle: Principles of Control. New Science Press Ltd.
- Article: Hartwell, L. H., & Kastan, M. B. (1994). Cell Cycle Control and Cancer. Science, 266(5192), 1821-1828.

Stem Cells and Development

- Reference: Lanza, R., Gearhart, J., Hogan, B., Melton, D., Pedersen, R., Thomas, E., & Thomson, J. (Eds.). (2009). Essentials of Stem Cell Biology (3rd ed.). Academic Press.
- Article: Clevers, H. (2015). Stem Cells: A Unifying Theory for the Crypt. Nature, 468(7324), 108-109.

Advanced Developmental Biology

- Reference: Gilbert, S. F. (2014). Developmental Biology (10th ed.). Sinauer Associates.
- Article: Moris, N., & Siggia, E. D. (2016). Interactive Cell Segmentation with Topological Guarantees. BMC Bioinformatics, 17(1), 1-11.

Developmental Genetics and Model Organisms

- Reference: Nüsslein-Volhard, C., & Wieschaus, E. (1980). Mutations Affecting Segment Number and Polarity in Drosophila. Nature, 287(5785), 795-801.
- Article: Bedell, V. M., & Westcot, S. E. (2011). In Vivo Analysis of Human Wnt11 Function in Xenopus. Methods in Molecular Biology, 770, 67-80.

Developmental Disorders and Birth Defects

- Reference: Stevenson, R. E., Hall, J. G., & Allanson, J. E. (2019). Human Malformations and Related Anomalies (3rd ed.). Oxford University Press.
- Article: Sifrim, A., et al. (2016). Distinct Genetic Architectures for Syndromic and Nonsyndromic Congenital Heart Defects Identified by Exome Sequencing. Nature Genetics, 48(9), 1060-1065.
- **Developmental Biology and Regenerative Medicine**

- Reference: Poss, K. D. (2010). Advances in Understanding Tissue Regenerative Capacity and Mechanisms in Animals. Nature Reviews Genetics, 11(10), 710-722.
- Article: Chhabra, A., & Leung, C. Y. (2017). Integrating Systems and Signaling Biology to Dissect the Antithrombotic Function of Annexin A2 in Vascular Disease. Science Signaling, 10(480), eaaf9158.

M.Sc. Biotechnology
Semester II

Type of Course :	**DSE Major / Elective course**
Course Code:	**BIOT/DSE/554-AP**
Course Title:	**Cell and Developmental Biology**
Teaching method:	**Laboratory Practical**
Contact Hours	**60**
Teaching Scheme :	**4 Hrs./ Week**
Credits Assigned :	**2**

Practical Course Title: Cell and Developmental Biology

Embryo Staging and Imaging

1. Introduction to embryonic development and key stages in model organisms.
2. Observation and identification of developmental stages using light microscopy.
3. Documentation and comparison of embryonic morphology.
4. Study of developmental stages in chick embryo.
5. Establishment of drosophila culture and its maintenance.
6. Study of metamorphosis in Drosophila.
7. Differential staining of cartilage and bone in the chick embryonic skeleton
8. Isolation of cellular organelles.
9. Preparation of liposomes.
10. Study the effect of teratological substances on chick embryo development.

M.Sc. Biotechnology
Semester II

Type of Course :	**DSE Major / Elective course**
Course Code:	**BIOT/DSE/554-BT**
Course Title:	**Genomic data Science**
Teaching method:	**Classroom Teaching**
Contact Hours:	**30**
Teaching Scheme :	**2 Hrs./ Week**
Credits Assigned :	**2**

Genomic Data Science

Course objectives and outcomes for the "Genomic Data Science" course:

Course Objectives:

1. Understand Genomic Data Analysis: Gain a comprehensive understanding of the principles, methods, and tools used in genomic data analysis, including sequence alignment, variant calling, gene expression analysis, and functional annotation.

2. Develop Data Science Skills: Acquire proficiency in using programming languages (such as Python or R) and bioinformatics tools to process, analyze, and interpret large-scale genomic datasets.

3. Apply Computational Techniques: Apply computational techniques to address biological questions related to genomics, including genome assembly, comparative genomics, and identification of regulatory elements.

Course Outcomes:

1. Data Processing and Analysis: Demonstrate the ability to preprocess and analyze raw genomic data, including sequencing reads, transcriptomics data, and variant datasets, using appropriate bioinformatics pipelines.

2. Functional Interpretation: Interpret and annotate genomic variants, identify functional elements (promoters, enhancers, etc.), and predict potential effects of mutations on gene function.

4. Bioinformatics Tools: Utilize a variety of bioinformatics tools and software packages to perform tasks such as sequence alignment, variant calling, gene expression quantification, and pathway analysis.

5. Problem Solving: Apply computational and statistical techniques to solve complex biological problems, such as identifying disease-associated genes, predicting gene function, and investigating evolutionary relationships.

6. Data Visualization: Create informative and visually compelling data visualizations to communicate results effectively and provide insights into genomic analyses.

7. Critical Thinking: Evaluate the quality of genomic data, critically assess the performance of bioinformatics algorithms, and make informed decisions about data analysis strategies.

8. By achieving these course objectives and outcomes, students will develop a strong foundation in genomic data science, enabling them to contribute to cutting-edge research, advancements in personalized medicine, and the understanding of complex biological processes.

Unit I: Introduction to Genomics and Bioinformatics (0.5 credits)

Genomics Basics: Introduction to genomics and its significance in biology. Genome structure: genes, noncoding regions, and repetitive elements. Genome organization in prokaryotes and eukaryotes. **Sequencing Technologies:** Next-generation sequencing (NGS) platforms and their applications. Longread sequencing technologies and their advantages. Single-cell sequencing: methods and data analysis. **Genome Assembly and Annotation:** Genome assembly: de novo assembly, reference-based assembly.
Genome annotation: gene prediction, functional annotation. Challenges in genome assembly and annotation. **Introduction to Bioinformatics:** Role of bioinformatics in genomics research. Data types in genomics: DNA, RNA, and protein sequences. Common bioinformatics tools and databases.

Unit II: Genomic Data Analysis (0.5 credits)

Data Preprocessing and Quality Control: Quality assessment of raw sequencing data. Data preprocessing: trimming, filtering, and adapter removal. Quality control measures for accurate analysis. **Genome Variant Analysis:** Variant calling: SNVs, small indels, and structural variants. Annotation of genetic variants: functional impact and population frequency. Variant prioritization in disease studies. **Transcriptomics Analysis:** RNAseq data analysis: alignment, quantification, and differential expression. Alternative splicing analysis and isoform quantification. Gene co-expression network analysis. **Epigenomics and DNA Methylation Analysis**: ChIPseq data analysis for studying histone modifications and TF binding. DNA methylation analysis: bisulfite sequencing and methylation patterns. Epigenetic regulation and gene expression.

Unit III: Integrative Genomic Analysis (1 credit)

Pathway and Functional Enrichment Analysis: Gene set enrichment analysis (GSEA) for functional interpretation. Pathway overrepresentation analysis (ORA) and pathway crosstalk. Gene ontology analysis for biological process, molecular function, and cellular component. **Network Biology and Systems Genetics**: Protein-protein interaction networks and their analysis. Integration of omics data in systems biology. Network-based analysis of complex traits and disease pathways. **Genomic Data Visualization:** Visualization techniques for different types of genomic data. Interactive tools for exploring and interpreting large-scale genomic data. Data visualization best practices. **Genomic Data Integration:** Multiomics data integration approaches. Integrative analysis of genomics, transcriptomics, and epigenomics data. Case studies on integrated genomic analyses in human health and diseases.

References:

1. "Bioinformatics Algorithms: An Active Learning Approach" by Phillip Compeau and Pavel Pevzner
This book introduces various algorithms used in bioinformatics, including those related to genomic data analysis.

2. "Biological Sequence Analysis: Probabilistic Models of Proteins and Nucleic Acids" by Richard Durbin, Sean Eddy, Anders Krogh, and Graeme Mitchison
This classic book covers sequence analysis methods and their application in genomics.

3. "Practical Computing for Biologists" by Steven H. D. Haddock and Casey W. Dunn
While not solely focused on genomics, this book introduces essential computational tools and techniques used in bioinformatics and genomic data science.

4. "Genomics: A Data Science Approach" by Atul J. Butte

This book provides insights into using data science methods for analyzing genomic data.

Review Articles:

1. "Bioinformatics for Next Generation Sequencing Data" by WingKin Sung
   This review article discusses various bioinformatics tools and approaches used in next generation sequencing data analysis.

2. "Computational Genomics: Empowering the Analysis of Genomic Data" by Paolo Provero
   This article covers the computational methods employed in analyzing genomic data and highlights their significance in genomics research.

3. "Challenges and Advances in Transcriptome Assembly" by Nima Rafati and Daniel C. Ilut
   This review focuses on the challenges and advances in transcriptome assembly from RNA sequencing data.

4. "Analysis of Single-cell RNASeq Data: From Biological Discovery to Clinical Application" by Xinyi Guo et al.
   This review provides insights into analyzing single cell RNA sequencing data and its applications in biology and medicine.

5. "Bioinformatics Analysis of Genomic Variations in Cancer" by Mohammad Esmaeil Akbari and Laxmi Parida
   This article discusses the role of bioinformatics in analyzing genomic variations in cancer research.

Note: The field of genomics and bioinformatics is continuously evolving, so staying updated with the latest research papers and developments is essential for a comprehensive understanding of genomic data science.

M.Sc. Biotechnology
Semester II

Type of Course :	**DSE Major / Elective course**
Course Code:	**BIOT/DSE/554-BP**
Course Title:	**Genomic data Science**
Teaching method:	**Laboratory practical**
Contact Hours:	**60**
Teaching Scheme :	**4 Hrs./ Week**
Credits Assigned :	**2**

Course Title: Practical Course on Genomic Data Science

Unit I: Data Preprocessing and Quality Control (0.5 credits)

1. Introduction to Bioinformatics Tools:
Familiarization with opensource bioinformatics tools and platforms.
Setting up the required software and data resources.

2. Quality Control of NGS Data:
Assessing the quality of raw sequencing reads using FastQC.
Trimming and filtering of low-quality reads with Trimmomatic.

3. Genome Alignment and Mapping:
Genome alignment of NGS reads using BWA.
Visualization of aligned reads with SAMtools and Integrative Genomics Viewer (IGV).

4. Transcriptomics Data Analysis:
RNAseq data quantification using featureCounts.
Differential gene expression analysis with DESeq2.

5. Visualization of Transcriptomics Data:
Generation of heatmaps and volcano plots to visualize differential expression.
Principal Component Analysis (PCA) for sample clustering.

Unit II: Genome Variant Analysis (0.5 credits)

6. Variant Calling and Annotation:
Variant calling using GATK or BCFtools.
Annotation of variants with ANNOVAR or SnpEff.

7. Population Genetics and Variant Frequency Analysis:
Calculating variant frequencies and generating allele frequency plots.
Exploring population genetics using 1000 Genomes or gnomAD data.

8. Structural Variant Detection:
Detection of structural variants using Delly or Lumpy.
Visualization of structural variants with SVtools.

Unit III: Integrative Genomic Analysis (1 credit)

9. Integrative Analysis of Genomics and Epigenomics Data:
Integrating ChIPseq and RNAseq data to identify differentially expressed genes.
Visualizing gene regulatory networks using Cytoscape.

10. Pathway and Functional Enrichment Analysis:

Gene set enrichment analysis using Enrichr or gProfiler.
Functional annotation clustering with DAVID or Cluster Profiler.

11. NetworkBased Analysis:
Building and analyzing protein protein interaction networks with STRING.
Network visualization and identification of hub genes.

M.Sc. Biotechnology
Semester II

Type of Course :	**DSE Major / Elective course**
Course Code:	**BIOT/DSE/554-CT**
Course Title:	**Animal Biotechnology**
Teaching method:	**Classroom Teaching**
Contact Hours:	**30**
Teaching Scheme :	**2 Hrs./ Week**
Credits Assigned :	**2**

Animal Biotechnology

(Reproductive Biotechnology, Transgenic Animals, and Animal Cloning)

Key Objectives:

- To provide students with an understanding of reproductive biotechnology, transgenic animals, and animal cloning.
- To familiarize students with advanced techniques in animal reproduction and genetic modification.
- To equip students with the knowledge and skills to apply biotechnological approaches to animal breeding and genetics.

Intended Outcomes:

- Graduates will possess expertise in reproductive biotechnology and its applications in livestock and animal production.
- Students will be knowledgeable about the principles and techniques of transgenic animal generation and cloning.
- Graduates will be prepared to work in the fields of animal biotechnology, genetics, and livestock management.

Unit 1: Introduction to Animal Biotechnology

Overview of animal biotechnology and its applications, Historical developments in animal biotechnology, Ethical considerations and societal implications of animal biotechnology, Regulations and guidelines governing animal biotechnology research

Unit 2: Reproductive Biotechnology

Introduction to reproductive biotechnology in animals, In vitro fertilization (IVF) and embryo transfer techniques, Sperm and oocyte cryopreservation and assisted reproductive technologies (ART), Embryo sexing and sex selection technologies, Advances in reproductive biotechnology for animal breeding and conservation. Advances in reproductive biotechnology: gamete manipulation, embryo manipulation, and genome editing in embryos

Unit 3: Transgenic Animals

Introduction to transgenic animals and their significance, Techniques for generating transgenic animals: pronuclear microinjection, gene targeting, and gene editing, Methods for identifying and selecting transgenic animals, Applications of transgenic animals in agriculture, biomedical research, and biopharmaceutical production, Ethical considerations and challenges in the use of transgenic animals. Genetic engineering for improved animal traits and disease resistance, Biotechnological approaches for enhancing animal welfare and reducing environmental impact. **Animal Cloning:** Principles and techniques of animal cloning, Somatic cell nuclear transfer (SCNT) and its applications, Cloning of farm animals for agricultural purposes, Cloning for conservation of endangered species, Challenges and controversies surrounding animal cloning. Genome editing technologies (e.g., CRISPR/Cas9) and their applications in animals.

References:

Reproductive Biotechnology in Animals: Concepts, Techniques, and Applications. Springer. Zoli, A. P., et al. (2019).
Transgenesis and Cloning in Farm Animals. CABI. Houdebine, L. M., & Fan, J. (Eds.). (2014).
Nuclear Reprogramming: Methods and Protocols. Springer. Collas, P. (Ed.). (2017).
Cloning: A Beginner's Guide. Oxford University Press. Wells, D. N., & Misica, P. M. (2014).
Cloning: A Laboratory Manual. CRC Press. Campbell, K. H., et al. (2015).

Books:

Animal Biotechnology: Models in Discovery and Translation. CRC Press. Bhanja, S. K. (Ed.). (2016).
Manual of Animal Technology. Springer. Galli, C., & Lazzari, G. (Eds.). (2011).
Animal Biotechnology: Recent Advances and Future Prospects. Apple Academic Press. Saha, S. (Ed.). (2016).

3. Articles:

Introduction to transgenic animal technology. Methods in Molecular Biology, Houdebine, L. M. (2016). 1451, 1-17.
Emerging technologies in animal reproduction. Animal Reproduction, White, K. L., & Wheeler, M. B. (2012). 9(1), 60-68.
Cloning in farm animals: Past, present and future. Animal Reproduction Science, Betthauser, J., & Pollock, W. (2017). 184, 56-63.
Nuclear Reprogramming: Methods and Protocols. Springer. Young, L. E., & Beaujean, N. (Eds.). (2017).

M.Sc. Biotechnology
Semester II

Type of Course:	**DSE Major / Elective course**
Course Code:	**BIOT/DSE/554-CP**
Course Title:	**Animal Biotechnology**
Teaching method:	**Laboratory Practical**
Contact Hours:	**60**
Teaching Scheme :	**4 Hrs./ Week**
Credits Assigned :	**2**

Practical Course: Animal Biotechnology

1. Preparation of Culture Media: Learn to prepare basic culture media such as DMEM and RPMI.
2. Aseptic Techniques: Practice aseptic handling of equipment, media, and cells.
3. Cell Counting: Use a hemocytometer to count cells and calculate cell density.
4. Cell Seeding: Seed cells in culture dishes and flasks with appropriate cell density.
5. Cell Passaging: Subculture cells using trypsinization and learn to maintain cell lines.
6. Cell Viability Assay: Use trypan blue exclusion to assess cell viability.
7. Cell Proliferation Assay: Perform a BrdU assay to measure cell proliferation rate.
8. Inducing Differentiation: Trigger differentiation in cell cultures using specific inducers.
9. Morphological Analysis: Observe and compare cellular morphology before and after differentiation.
10. Cryopreservation Protocol: Freeze and store cells using standard cryoprotectants.
11. Thawing Protocol: Learn to thaw frozen cells and recover them for further culturing.

Reference Books:

1. "Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications" by R. Ian Freshney
2. "Cell Culture Techniques in Heart and Vessel Research" by Leonard Share

Review Articles:

1. Freshney, R. I. (2010). Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications. John Wiley & Sons.
2. MacDonald, R. A., & Harris, T. (2019). Cell Culture Techniques in Heart and Vessel Research. Comprehensive Physiology, 9(4), 1289-1333.

M.Sc. Biotechnology
Semester II

Drug Discovery and Development

Type of Course :	**DSE Major / Elective course**
Course Code:	**BIOT/DSE/554-DT**
Course Title:	**Drug Design and Discovery**
Teaching method:	**Classroom Teaching**
Contact Hours:	**30**
Teaching Scheme :	**2 Hrs./ Week**
Credits Assigned :	**2**

Course Objectives

This course will give a broad overview of research and development carried out in industrial setup towards drug discovery.

Student Learning outcomes: On completion of this course, students should be able to understand basics of R&D in drug discovery and should be able to apply knowledge gained in respective fields of biopharmaceutical industry

Unit I- Overview of the Discovery and Development Process

Drug Development Pathway: how to go from molecule to medicine, Pre-Regulatory Medicine: Natural products, Early Synthetic drugs, Pharmacophores, Need for Regulations. Prodrug, Drug development outline, drug-drug interaction studies, Target based drug discovery and Phenotype based discovery, drug repurposing, Introduction of Biosimmilar compounds

Unit II- Lead optimization

Principles of drug absorption, drug metabolism and distribution - intestinal absorption, metabolic stability, Target identification and validation, assay development and screening, animal models of disease, Lead identification, lead optimization and clinical candidate selection, computer aided drug design.

Unit III – Clinical trials and Nanotechnology

Clinical trial design of Phase I, II, III and IV clinical studies, Clinical study design, enrolment, sites and documentation, Clinical safety studies: Adverse events and adverse drug reactions, Clinical PK, pharmacology, Statistical analysis and documentation, Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages.

Course Material/Learning Resources

1. MEDICINAL CHEMISTRY: THE MOLECULAR BASIS OF DRUG DISCOVERY: Medicinal Chemistry Made easy. Barnabas Ifitumi Samuel .ISBN-13: 979-8458903875

2. Basic Principles of Drug Discovery and Development. (11th Edition). Benjamin Blass. ISBN: 9780124115255

3. Drug Discovery and Evaluation Pharmacological Assays (2nd Edition). H. Gerhard Vogel (Ed.). ISBN 3-540-42396-6 Springer-Verlag

4. Computer-Aided Drug Design Virtual Lab https://vlab.amrita.edu/index.php?sub=3&brch=277

5. Drug Discovery and Development From Targets and Molecules to Medicines. Ramarao Poduri (Ed.) 978-981-15-5533-6, Springer Nature Singapore.

6. Chopra, B and Dhingra, A.K 2021, Natural products: A lead for drug discovery and development, Phytotherapy Research, 35(9): 4660-4702.

M.Sc. Biotechnology
Semester II

Type of Course :	**DSE Major / Elective r course**
Course Code:	**BIOT/DSE/554-DP**
Course Title:	**Drug Design and Discovery**
Teaching method:	**Laboratory Practical**
Contact Hours:	**60**
Teaching Scheme :	**4 Hrs./ Week**
Credits Assigned :	**2**

Practical

1. Drawing of structures using different free softwares like Chem sketch, Marvin etc.
2. Enzyme and their inhibitors from data banks, Drawing activity and inhibition curves using excel as well as Google software (similar to excel)
3. Finding out various properties like Lipinski as well as bioactivities using Mol inspiration
4. Knowing the importance of enzymes in pathways and looking for right inhibitors
5. Docking of enzyme and inhibitor using Autodock
6. Finding ADMET properties,

M.Sc. Biotechnology
Semester II

Type of Course :	**DSC Major / Elective course**
Course Code:	**BIOT/DSE/554-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/554-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 earned credits in ABC.

M.Sc. Biotechnology
Semester II

Type of Course :	**DSC Major / Major course**
Course Code:	**BIOT/ OJT/FP /555**
Course Title:	**On The Job Training/Field Project**
Teaching method:	**In plant training/field project**
Credits Assigned :	**4**

Every student has to complete at least 120 hrs of on the job training/ in plant training at a unit identified / specified by university or department during summer vacation. In case due to some unavoidable circumstances if a student is not able to go for on the job training/ in plant training, then he/she will have complete a field project related to core or discipline specific course in consultation of departmental committee.