**M Sc (Medical Biotechnology) 2 years degree**

**Under Regulations- (R-2025)**

**(w.e.f. 2025-26 admitted batch)**

**Course Structure and Syllabi**


**THE APOLLO UNIVERSITY**

**MURUKAMBATTU - CHITTOOR (Dt) 517127**

**ANDHRA PRADESH**

**Program Educational Objectives (PEOs)**

The M.Sc. Medical Biotechnology program aims to:

1. **PEO 1 – Core Competency**

   Prepare postgraduates with in-depth theoretical and practical knowledge in medical

biotechnology, focusing on molecular biology, immunology, cell biology, and genetic engineering relevant to human health and disease.

2. **PEO 2 – Research and Innovation**
   Enable students to pursue research and innovation in medical biotechnology, contributing to scientific advancements in diagnostics, therapeutics, and regenerative medicine.
3. **PEO 3 – Ethics and Professionalism**
   Instill a strong foundation in bioethics, regulatory affairs, and professional practices essential for responsible research and biotechnology applications in healthcare.
4. **PEO 4 – Career and Industry Readiness**
   Prepare students for careers in biotechnology industries, clinical laboratories, pharmaceutical companies, and research institutions through domain-specific training and skill development.
5. **PEO 5 – Lifelong Learning and Leadership**
   Encourage continuous learning, higher education, entrepreneurship, and leadership roles in academia, industry, and public health biotechnology.

**Program Outcomes (POs)**

Upon successful completion of the program, graduates will be able to:

1. **PO 1 – Knowledge Integration**
   Demonstrate comprehensive understanding of biological systems and their application in disease diagnosis and therapy.
2. **PO 2 – Technical Proficiency**
   Apply laboratory techniques in molecular biology, genetic engineering, and immunodiagnostics with precision and adherence to quality standards.
3. **PO 3 – Research Capability**
   Design and conduct scientific research, analyze data, and interpret findings in alignment with current trends in medical biotechnology.
4. **PO 4 – Problem Solving and Innovation**
   Identify biomedical problems and develop biotechnological solutions using innovative and evidence-based approaches.
5. **PO 5 – Computational Skills**
   Utilize bioinformatics tools and data analysis software for interpreting genomic, proteomic, and transcriptomic data.

6. **PO 6 – Communication**
   Communicate scientific ideas and research outcomes effectively through oral, written, and digital platforms.
7. **PO 7 – Ethics and Safety**
   Follow ethical principles, biosafety norms, and regulatory guidelines in clinical and laboratory settings.
8. **PO 8 – Multidisciplinary Collaboration**
   Collaborate with interdisciplinary teams in research, diagnostics, and public health initiatives.
9. **PO 9 – Entrepreneurial Thinking**
   Demonstrate entrepreneurial skills in the development of diagnostics, therapeutics, or biotech-based innovations.
10. **PO 10 – Societal and Environmental Awareness**
    Understand the implications of biotechnological advancements on society, health, and the environment.
11. **PO 11 – Project Management**
    Apply principles of project planning, management, and documentation in laboratory and industrial research settings.
12. **PO 12 – Lifelong Learning**
    Engage in self-directed learning and professional development in response to advancements in science and technology.

**Program Specific Outcomes (PSOs)**

Graduates of the M.Sc. Medical Biotechnology program will be able to:

1. **PSO 1 – Clinical Biotechnology Applications**
   Apply molecular diagnostics, immunoassays, and cell-based techniques in clinical and translational research settings.
2. **PSO 2 – Therapeutic Development**
   Participate in the development and validation of biopharmaceutical products such as monoclonal antibodies, vaccines, and gene therapies.
3. **PSO 3 – Omics-Driven Research**
   Integrate genomics, proteomics, and systems biology approaches to understand disease mechanisms and identify biomarkers.
4. **PSO 4 – Research and Industry Preparedness**
   Exhibit competence for roles in R&D, biotech industries, and clinical research organizations through hands-on and project-based learning.
5. **PSO 5 – Public Health Biotechnology**
   Contribute to public health initiatives using biotechnological strategies for disease surveillance, diagnostics, and health education.

# THE APOLLO UNIVERSITY
# ACADEMIC REGULATIONS

**SCOPE:**

This Academic regulation provide a framework for the regulatory guidelines of all programs offered by The Apollo University. It includes procedures and practices that are to be followed to ensure academic standards in the University. The regulations are approved by the Academic Council. These regulations may be amended from time to time with the approval of the Academic council for the benefit of students or some times to reflect the changes suggested by the statutory bodies.

Information regarding amendments (if any) to the regulations will be communicated to the students by publishing in the University website. Students must follow the amended regulations as they might impact the process for the award of degree. The decision of the Vice Chancellor shall be the final in case of any discrepancy. These regulations apply to all students, despite the program of study.

## 1. ADMISSION INTO THE PROGRAM

The University admits the students in two modes. One through the convenor quota as per the Andhra Pradesh Private Universities Act, for which the admissions will be carried out through the convener quota by the Govt of Andhra Pradesh. The other is through University quota for which the following procedure will be followed:

A. The applicant shall satisfy the entrance requirements specified by The Apollo University and in accordance with guidelines of statutory councils for Under-graduation.
B. The Applicant shall be qualified in the qualifying examination for a particular program.
C. The Applicant secures a rank in national level entrance exam or suitable such test conducted by The Apollo University / professional body.
D. The Applicant qualifies in the specified state or national level examinations prescribed by The Apollo University.

The Apollo University will widely notify the counselling schedule for admissions into the academic programs in the media. The provisional admission will be given to the eligible students during the counseling scheduled by The Apollo University. The selected candidates will be provisionally admitted into the program of his/her choice if the candidate meets the program specific requirements in addition to academic performance qualifying exam. Admission is purely based on merit and so merely meeting the requirements will not ensure

admission. The University does not discriminate based on gender, race, region, religion, disability or nationality. The University reserves the right to make admissions based on various criteria which is specified in the admission brochure.

## 2. ELIGIBILITY CRITERIA

### Undergraduate programs

The qualifying exam eligibility for each program is given Annexure 1. The student should have passed the qualifying exam either in the year the student is seeking admission or the previous year.

**Convener Quota:** The student seeking admission to any program under convener quota shall qualify in the relevant entrance exam conducted by the Government of Andhra Pradesh.

**University Quota:** For getting admission under university quota, percentage of marks obtained in the qualifying exam, the rank obtained in TAU entrance exam or any recognized national level examination in the year of admission will be considered.

### Counselling

All the eligible students need to apply for admission and have to attend counselling conducted by TAU as per the schedule for the university quo

## 3. PROGRAMS

The Apollo University offers variety of programs which includes certificate, undergraduate, postgraduate, and Research. The list of programs on offer for the academic year 2025- 2026 are annexed in Annexure 2 and those of 2023-24 are annexed in Annexure 3.

### Minimum duration of the program

The minimum duration of each program depends on the type of program, viz., undergraduate, postgraduate, integrated programs, etc., and the faculty which offers the program. The maximum duration of the program is N+2 years, where N stands for the minimum duration of the program as mentioned in Annexure 2 and 3. If the student has not obtained the minimum number of credits within the stipulated time, the Vice-Chancellor may extend the maximum duration in extenuating circumstances upon receiving a request along with reasons from the student for not completing the program on time.

## 4. CHOICE BASED CREDIT SYSTEM

The choice-based credit system (CBCS) facilitates the education student-centric. It provides the opportunity for the learner to choose the courses from a basket of core, elective, and skill enhanced courses. All programs of study are designed to meet the specified number of credit requirements. The courses taken by the student in each semester as part of program are allotted some credit points based on the number of hours assigned. Upon successful completion of the course, the student secures the number of credits allotted for that course. Once the minimum number of credits of the program is achieved, the degree can be awarded, subject to fulfilment of all other relevant conditions.

**5. STRUCTURE OF THE PROGRAM**

The Program structure Consists of

i) University Courses
   A. University Core
   B. University Electives
ii) Faculty Courses
   A. Faculty Core
   B. Faculty Electives
iii) Program Courses
   A. Program Core
   B. Program electives

Each course* is assigned a certain number of credits depending upon the number of contact hours (lectures/tutorials/practical) per week. (*one course means one subject)

Core Courses = 3 Credits /4 Credits Elective =3 Credits

In general, credits are assigned to the courses as detailed below:

- A classroom lecture/ tutorial of 60 min (1 hr) duration per week, spread over the entire semester, shall be considered as one credit.
- A laboratory session of minimum of 120 min (2 hr) per week shall be considered as one credit.
- A project work/ Internship session of 60 minutes (1 hr) carried out per week shall be considered as one credit.

**6. MEDIUM OF INSTRUCTION**

The medium of instruction (including examinations and project reports) shall be English.

**7. REGISTRATION**

Any of the following student must register for the courses opted in a particular semester during the scheduled registration period.

i. a new student who enrolls into any program
ii. an existing student who is continuing on rolls from the preceding regular semester
iii. a former student, i.e., who has not enrolled in the preceding regular semester or who has availed academic break or detained and got readmission

Each newly admitted student shall attend an induction/ orientation program prior to commencement of the first semester. During this program academic advisors assist the students in choosing the courses. Existing student may register online by using their registration number and mail ID through the Apollo ERP portal. Class schedules are available approximately two weeks before the beginning of every semester for each program. The concerned head of the department must approve class schedule.

**8. ATTENDANCE REQUIREMENTS**

- Students should earn a minimum of 80% attendance in the current semester to become eligible to write the Semester End Examinations.
- The monthly statement of attendance will be displayed on the Department Notice Board/ Apollo ERP by the respective departments within the first five working days of the following month.
- Candidates who are falling short of 80% attendance will be detained on the recommendation of the HoD and are not eligible to appear for the current semester examinations. The students who are detained in the current semester will not be allowed to register for the next semester and they have to repeat the same semester by paying the tuition fee prescribed. However, they can write arrear subjects, if any.

**9. EVALUATION**

The assessment of the student's performance in a Theory course shall be based on two components: Continuous Evaluation (40 marks) and Semester-end examination (60 marks). A student has to secure an aggregate of 40% in the course in the two components put together to be declared to have passed the course, subject to the condition that the candidate must have secured a minimum of 24 marks (i.e. 40%) in the theory component at the semester-end examination. Practical/ Project Work/ Industrial Training/ Viva voce/ Seminar etc. are completely assessed under Continuous Evaluation for a maximum of 100 marks, and a student has to obtain a minimum of 50% to secure

Pass Grade. For courses having both theory and practical components, 60% of the weightage will be given for theory component and 40% weightage for practical component. The student must secure 40% (Theory + Practical) with 24 marks minimum in theory to attain pass grade.
Details of Assessment Procedure are furnished below in Table 1.

**Table 1: Assessment Procedure**

| S. No. | Component of Assessment | Marks Allotted | Type of Assessment | Scheme of Evaluation |
|---|---|---|---|---|
| 1 | Theory | 40 | Continuous Evaluation | i) Twenty (20) marks for mid examinations. Three mid examinations shall be conducted for 20 marks each; average of the best two performances shall be taken into consideration.<br>ii) Ten (10) marks for Quizzes, Assignments and Presentations.<br>iii) Ten (10) marks for periodic evaluation, case studies and projects |
| | | 60 | Semester-end Examination | iv) Sixty (60) marks for Semester-end examinations |
| | **Total** | **100** | | |
| 2 | Laboratory | 100 | Continuous Evaluation | 1)80 marks with equal weightage to all experiments subject to conduct of minimum of 10 experiments<br>2)20marks for the end exam (with one of our university teachers as external other than course teacher) |
| 3 | Internship | 100 | Continuous Evaluation | i) (80) marks for periodic evaluation of Internship report by the Project Supervisor.<br>ii) Twenty (20) marks for final Report presentation and Viva-voce, by a panel of internal examiners. |

| | | | | |
|---|---|---|---|---|
| | | | | iii) Students shall undergo TWO internships during the course of time and the evaluation shall be done during final semester. |
| 4 | Project work | 100 | Continuous Evaluation | iv) (80) marks for periodic evaluation and technical report writing by the Project Supervisor.<br>ii) Twenty (20) marks for final Report presentation and Viva-voce, by a panel of internal examiners |
| 5 | Students Seminars | 100 | Continuous Evaluation | Each student has to give a seminar on any topic in consultation with the faculty member in charge A detailed report shall be submitted to the in charge.<br>60 marks for periodic evaluation including report preparation and 40 marks for viva voce by a panel of examiners. |

**GRADING SYSTEM**

Based on the student performance during a given semester, a final letter grade will be awarded at the end of the semester in each course. The letter grades and the corresponding grade points are as given inTable2.

**Table 2: Grades & Grade Points**

| **Sl. No.** | **Grade** | **Grade Points** | **Absolute Marks** |
|---|---|---|---|
| 1 | O(Outstanding) | 10 | 90 and above |
| 2 | A+(Excellent) | 9 | 80 to 89 |
| 3 | A (Very Good) | 8 | 70 to 79 |
| 4 | B+(Good) | 7 | 60 to 69 |
| 5 | B (Above Average) | 6 | 50 to 59 |
| 6 | C(Average) | 5 | 45 to 49 |
| 7 | P(Pass) | 4 | 40 to 44 |
| 8 | F(Fail) | 0 | Less than 40 |
| 9 | Ab. (Absent) | 0 | - |

**SEMESTER GRADEPOINTAVERAGE (SGPA)**

A Semester Grade Point Average (SGPA) for the semester will be calculated according to the formula:

$$\text{SGPA} \frac{\sum [\text{C X G}]}{\sum \text{C}}$$

Where

C=number of credits for the course,

G=grade points obtained by the student in the course.

A student who earns a minimum of 4 grade points (P grade) in a course is declared to have successfully completed the course, and is deemed to have earned the credits assigned to that course.

**CUMULATIVE GRADE POINT AVEARGE (CGPA)**

A similar formula is used to arrive at Cumulative Grade Point Average (CGPA), considering the student's performance in all the courses taken in all the semesters up to the particular point of time. Table 3 shows the CGPA required for the award of class after the successful completion of the program.

**Table3: CGPA required for award of Class**

| **Class** | **CGPA Required** |
|---|---|
| First Class with Distinction | ≥8.0* |
| First Class | ≥6.5 |
| Second Class | ≥5.5 |
| Pass Class | ≥5.0 |

*In addition to the required CGPA of 8.0 or more, the student must have necessarily passed all the courses of every semester in first attempt.

**11. REAPPEARANCE**

a. A student who has secured 'F' grade in a Theory course shall have to reappear at the subsequent Semester end examination held for that course.
b. A student who has secured 'F' grade in a Practical course shall have to attend Special Instruction Classes scheduled by the Department for securing pass.
c. A student who has secured 'F' Grade in Internship /Project work / Industrial Training etc shall have to reappear for Viva – voce scheduled by the department.
d. A student who is declared fail (F) in a course/s can apply for revaluation within one week from the date of publication of results with a fee prescribed by the university.

The marks /grade awarded in the revaluation is final.

### 11.1 Procedure for revaluation

- The students who have not satisfied with the marks awarded by the examiner can apply for revaluation of his/her answer script/s
- The students have to apply through proper channel for revaluation and to pay the revaluation fee per paper to the university towards revaluation fee.
- Students have to apply for revaluation within 7 days from the date publication of result.
- The scripts will get valued by second examiner and if the difference is more than 15 marks, they will get valued by the third examiner. The average of the nearest two marks will be declared as the final marks.

### 11.2 ASSESSMENT MECHANISM

The Apollo University offers a student the benefits of Choice Based Credit System. Every paper is allotted a certain number of credits as per the UGC norms. A student is awarded the specified credits on obtaining a pass in the respective paper.

The Choice Based Credit System (CBCS) has been adopted for UG Course from the year 2021-22 onwards as per the recommendations of the A.P. State Council for Higher Education (APSCHE). The structure of undergraduate programmes provides a wide range of choice for students to opt for courses based on their eligibility, aptitude and career goals.

### 11.3 Semester End Examination

The End semester examination will be a comprehensive examination of 3 hours duration. Two End Semester examinations are conducted in a year-

Odd semester examinations in November/ December and

Even semester examination in May/June

Practical examination / Project viva will be held 2 weeks prior to the theory semester end examinations.

**Under-Graduation Programs**

| Course | Continuous Assessment | End semester | Aggregate in End semester Examinations |
|---|---|---|---|
| All UG Courses | No passing minimum | 40% | 40% |

### 11.4 Post Evaluation Programme:

Under the Post Evaluation Programme there are three menus:

- Provision for improvement
- Re-totalling and Revaluation of answer scripts
- Restrictions to appear for the examinations

### 11.5 Provision for improvement

A student who passes a paper in the first attempt can reappear for the same paper in the succeeding End-of-Semester examination only, for improving his/her marks. Re-appearance for improvement is allowed for theory and practical subjects of all semesters, except for the final semester subjects. Revised mark statement will be issued after withdrawing the previous one, if the marks obtained in improvement are higher than the marks awarded earlier. When there is no improvement, there shall not be any change in the original marks already awarded. The improved marks shall be considered for classification but not for ranking.

Provision for Re-totaling and Revaluation of valued answer scripts

- UG candidates may apply for re-totaling / revaluation of valued answer scripts, to the Controller of Examinations through the Heads of Departments and Principal / Dean, in the prescribed forms, remitting the prescribed fee within 7 days from the

date of publication of results. Revaluation of answer scripts is permissible only for the current semester papers and not for any arrear paper.

- Those wish to apply for revaluation of final semester papers can do so within five days from the date of publication of results. In re-valuation, the answer papers will be valued by an external examiner and if there is a difference of 15 marks between the two evaluations then the script will be sent for third valuation which is final and the mark awarded by the third examiner will be taken into the account.
- Revised mark statement will be issued after withdrawing the previous one, if the marks obtained in revaluation / retotalling are higher than the marks obtained earlier. In other cases, the original marks obtained earlier will be retained and the matter will be intimated to the student concerned as 'No change'.
- A candidate who applies for revaluation should not apply for retotalling.

**Restrictions to appear for the examinations**

Candidates who fail in any of the papers in the UG End semester examinations shall complete the paper concerned within N+2 years from the date of admission to the particular course. If they fail to do so, they shall re-register their names and take the examination in the texts/revised regulations/syllabus of the paper prescribed for the subsequent batch of candidates, in force at the time of their reappearance. In the event of removal of that paper consequent to change of regulation and/or curriculum after N+2 years period, the candidate shall have to take up an equivalent paper in the revised syllabus as suggested by the Chairman, Board of Studies concerned.

**12. BETTERMENT OF GRADES**

A student who has secured only a Pass or Second class and desires to improve his/her Class can appear for Betterment Examinations only in Theory courses of any Semester of his/her choice, conducted in Summer Vacation along with the Special Examinations. Betterment of Grades is permitted 'only once' immediately after completion of the program of study.

**13. DETENTION AND RE-ADMISSION**

If a student fails to meet the minimum attendance requirement or minimum standards for academic progression, the concerned academic head will recommend for detention and it will be notified by the concerned Dean of the School. The students who are detained in the current semester will not be allowed to register for the next semester and they have to repeat the same semester.

The candidates who are detained or availed academic break or suspended in the previous semester/academic year and want to continue their study shall apply for re-admission to the university. The candidates shall request for re-admission to the respective Head of the Department, with details viz., Full Name, Registration Number, Department, School, Fee payment particulars with proofs and reasons for discontinuations. The concerned academic head will forward it to the Registrar with specific comments. The Registrar will notify the decision of re-admission which shall include the prescribed fee particulars, semester/ year into which readmission is granted and additional courses to be completed by the student (if any). The candidates should apply for re-admission in advance, that is before the commencement of the semester.

## 14. GROOMING AND ATTIRE FOR STUDENTS

Grooming and Etiquette is of great significance in the dynamic of shaping one's Personality. The Apollo University stands by a Code of Grooming, Attire and Etiquette that promotes a professional standard: Academic Day; Campus Placements and Non-Academic Hours on Campus.

The Dress Code to be in compliance on academic premises while attending: Formal Functions of the Institution / Lectures / Practicals / Dining Area / Library / Labs / Office Areas.

Students shall follow appropriate attire during Academic and Non-Academic hours on the campus. Students shall wear clean, neat, pressed and presentable clothing, and command respect by dressing in accordance with responsible personal norms. Students shall always wear The Apollo University ID Card with the Lanyard.

**Grooming and Formal Wear - Boys:**

Formal Shirts / T-Shirts with a Collar should preferably be tucked in with a Formal pair of Pants Shoes and Socks to complete the Formal Attire. Personal Hygiene should be followed and Hair should be well groomed.

**Smart Casuals for Boys:**

Long Kurtas / Formals / Semi-Formal Shirts with Jeans.

Grooming and Formal Wear - Girls: Sarees / Salwar Suits / Leggings or Jeggings with Long Kurtis / Long Frocks / Long Skirts / Palazzos. Complement the outfit with proper footwear. Personal Hygiene should be followed and Hair should be well groomed.

**Smart Casuals for Girls:**

Jeans with long Kurtis / Long Skirts / Long Frocks.

Attire for Non-Academic Hours On Campus:

The students should be neatly attired during Non-Academic Hours on Campus.

**Dress Code for Boys:**

Jeans / Track Suits / T-Shirts / Trousers / Shirts.

Dress Code for Girls:

Jeans / T-Shirts or Blouses / Salwar Suits / Palazzos / Leggings or Jeggings with Long Tops / Sarees / Long Skirts / Track Suits.

**DO'S AND DO'NTS FOR BOYS AND GIRL STUDENTS OF THE UNIVERSITY:**

- To wear modest clothing that reflects the essence of good personal grooming standards.
- To refrain from wearing Sleeveless Clothing; Shorts; Short Tops, etc.,

PLEASE NOTE: The decision as to what constitutes Appropriate Attire vests with the Authorities of The Apollo University.

## 15. ELIGIBILITY FOR AWARD OF THE DEGREE

The undergraduate degree will be of 3-years of duration. A student shall be declared as eligible for the award of the degree if the candidate has successfully secured the minimum number of required credits as specified in the curriculum corresponding to the branch of his/her study within the stipulated time.

After successful completion of the program, a provisional certificate cum memorandum of grades (PCMG) will be issued to the students. The PCMG includes the secured grades and class achieved in chosen program and specialization if any, along with grades and CGPA secured by the student. The original degree will be presented in the subsequent convocation.

## 16. DISCRETION POWER

Not with-standing anything contained in the above sections, the Vice Chancellor may review all exceptional cases, and give his decision, which will be final and binding.

## ANNEXURE 1

## ELIGIBILTY FOR QUALIFYING EXAM FOR UNDER GRADUATE PROGRAMS

| Program Type | Program Name | Eligibility |
|---|---|---|
| Master's | **M Sc., MBT – Medical Biotechnology** | A bachelor's degree in any branch of Life Sciences/Technology (Botany, Zoology, Microbiology, Biochemistry, Biotechnology, Genetics, Agriculture or equivalent) and Health/Medical Sciences (Medicine, Dental, Nursing, Pharmacy, Allied Health Sciences, Veterinary or equivalent) from any recognized Indian or Foreign University are eligible to apply. Students with B.Sc. degree in Physical and Chemical Sciences are also eligible to apply provided if biology is taken as one of the subjects at + 2 level. |

**ANNEXURE 2**

**PROGRAMS OFFERED BY DEPARTMENT OF BIOMEDICAL SCIENCES UNDER SCHOOL OF HEALTH SCIENCE**

**FROM ACADEMIC YEAR 2025- 2026**

| Sl. No. | Program | Expanded | Level | Minimum Duration in Years (N) |
|---|---|---|---|---|
| 1 | M Sc., MBT | Medical Biotechnology | Master's | 2 |

**ANNEXURE 3**

**PROGRAMS OFFERED BY**

**DEPARTMENT OF BIOMEDICAL SCIENCES**

**UNDER SCHOOL OF HEALTH SCIENCE**

**FROM ACADEMIC YEAR 2023-24**

| Sl. No. | Program | Expanded | Level | Minimum Duration in Years (N) |
|---|---|---|---|---|
| 1 | M Sc., MBT | Medical Biotechnology | Master's | 2 |

**M.Sc. Medical Biotechnology**

**Course Structure**

**(w.e.f 2025- 2026 batch)**

## I - Semester

| 3 Week Induction Programme | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **Course Name** | **Periods per week** | | | **Credits** | **Hours per week** |
| | | **L** | **T** | **P** | | |
| MBTT7501 | Cell and Molecular Biology | 3 | 1 | 0 | 4 | 4 |
| MBTT7502 | Biochemistry and Metabolism | 3 | 1 | 0 | 4 | 4 |
| MBTT7503 | Microbiology and Immunology | 3 | 1 | 0 | 4 | 4 |
| MBTT7504 | Techniques in Biotechnology – I | 3 | 1 | 0 | 4 | 4 |
| MBTT7505 | Biostatistics and Bioinformatics | 3 | 1 | 0 | 4 | 4 |
| MBTL7501 | Techniques in Cell Biology and Biochemistry Lab | 0 | 0 | 4 | 2 | 4 |
| MBTL7502 | Microbiology and Immunology Lab | 0 | 0 | 4 | 2 | 4 |
| -- | Soft Skills | 0 | 0 | 0 | 0 | 1 |
| -- | Mentoring | 0 | 0 | 0 | 0 | 1 |
| -- | Technical Seminar | 0 | 0 | 0 | 0 | 1 |
| -- | Library | 0 | 0 | 0 | 0 | 1 |
| -- | Physical Activity | 0 | 0 | 0 | 0 | 1 |
| -- | Sports & Club Activity Sessions | 0 | 0 | 0 | 0 | 1 |
| -- | Student Research Groups & Journal Clubs | 0 | 0 | 0 | 0 | 1 |
| -- | Self-Learning | 0 | 0 | 0 | 0 | 1 |
| **TOTAL** | | 15 | 5 | 8 | 24 | 36 |

**M.Sc. Medical Biotechnology**

**Course Structure**

**(w.e.f 2025- 2026 batch)**

## II - Semester

| 3 Week Induction Programme | | | | | | |
|---|---|---|---|---|---|---|
| **Course Code** | **Course Name** | **Periods per week** | | | **Credits** | **Hours per week** |
| | | **L** | **T** | **P** | | |
| MBTT7506 | Genetic Engineering and Recombinant DNA Technology | 3 | 1 | 0 | 4 | 4 |
| MBTT7507 | Molecular Diagnostics | 3 | 1 | 0 | 4 | 4 |
| MBTT7508 | Bioprocess Engineering and Fermentation Technology | 3 | 1 | 0 | 4 | 4 |
| MBTT7509 | Techniques in Biotechnology – II | 3 | 1 | 0 | 4 | 4 |
| MBTT7510 | Genomics and Proteomics | 3 | 1 | 0 | 4 | 4 |
| MBTL7503 | Genetic Engineering Lab | 0 | 0 | 4 | 2 | 4 |
| MBTL7504 | Molecular Diagnostics Lab | 0 | 0 | 4 | 2 | 4 |
| -- | Soft Skills | 0 | 0 | 0 | 0 | 1 |
| -- | Mentoring | 0 | 0 | 0 | 0 | 1 |
| -- | Technical Seminar | 0 | 0 | 0 | 0 | 1 |
| -- | Library | 0 | 0 | 0 | 0 | 1 |
| -- | Physical Activity | 0 | 0 | 0 | 0 | 1 |
| -- | Sports & Club Activity Sessions | 0 | 0 | 0 | 0 | 1 |
| -- | Student Research Groups & Journal Clubs | 0 | 0 | 0 | 0 | 1 |
| -- | Self-Learning | 0 | 0 | 0 | 0 | 1 |
| **TOTAL** | | 15 | 5 | 8 | 24 | 36 |

**M.Sc. Medical Biotechnology**

**Course Structure**

**(2025- 2026 admitted batch)**

## III - Semester

| Course Code | Course Name | Periods per week | | | Credits | Hours per week |
|---|---|---|---|---|---|---|
| | | L | T | P | | |
| MBTT8511 | Stem Cell Biology and Regenerative Medicine | 3 | 1 | 0 | 4 | 4 |
| MBTT8512 | Vaccine Technology | 3 | 1 | 0 | 4 | 4 |
| MBTT8513 | Pharmacogenomics and Personalized Medicine | 3 | 1 | 0 | 4 | 4 |
| MBTT8514 | Medical Biotechnology Applications | 3 | 1 | 0 | 4 | 4 |
| MBTT8601 | Elective I | 3 | 0 | 0 | 3 | 3 |
| MBTL8505 | Stem Cell and Immunotherapy Lab | 0 | 0 | 4 | 2 | 4 |
| MBTL8506 | Pharmacogenomics Lab | 0 | 0 | 4 | 2 | 4 |
| -- | Library | 0 | 0 | 0 | 0 | 2 |
| -- | Physical Activity | 0 | 0 | 0 | 0 | 2 |
| -- | Sports & Club Activity Sessions | 0 | 0 | 0 | 0 | 2 |
| -- | Student Research Groups & Journal Clubs | 0 | 0 | 0 | 0 | 3 |
| **TOTAL** | | 15 | 4 | 8 | 23 | 36 |

**M.Sc. Medical Biotechnology**

**Course Structure**

**(2025- 2026 admitted batch)**

## IV - Semester

| Course Code | Course Name | Periods per week | | | | Number of Hours |
|---|---|---|---|---|---|---|
| | | L | T | P | C | |
| MBTT8516 | Research Methodology and Scientific Communication (NPTEL/SWAYAM) | 1 | 1 | 0 | 2 | 2 |
| MBTT8517 | IPR and Regulatory Affairs (NPTEL / SWAYAM) | 1 | 1 | 0 | 2 | 2 |
| MBTT8602 | Elective II | 3 | 0 | 0 | 3 | 3 |
| MBTP8501 | Project Work | 0 | 0 | 24 | 12 | 24 |
| | Library | 0 | 0 | 0 | 0 | 1 |
| | Physical Activity | 0 | 0 | 0 | 0 | 1 |
| | Sports & Club Activity Sessions | 0 | 0 | 0 | 0 | 2 |
| | Student Research Groups & Journal Clubs | 0 | 0 | 0 | 0 | 1 |
| | TOTAL | 5 | 2 | 24 | 19 | 36 |

**Course Code: MBTT7501**

| L | T | P | C |
|---|---|---|---|
| 3 | 1 | 0 | 4 |

## Cell and Molecular Biology

### Course Description

This course provides a comprehensive understanding of cellular organization, molecular mechanisms, and cellular processes. Students will explore the fundamental principles of cell biology, including cell structure, function, and regulation, along with molecular aspects of gene expression, DNA replication, and cellular signaling.

### Course Objectives

1. Demonstrate comprehensive knowledge of cellular structures and their functions in both prokaryotic and eukaryotic cells
2. Analyze the molecular mechanisms underlying DNA replication, transcription, and translation
3. Evaluate cellular signaling pathways and their role in cell communication and regulation
4. Understand the principles of cell division, cell cycle regulation, and cellular differentiation
5. Examine current research methodologies in cell and molecular biology

### Program Core – 1: Cell and Molecular Biology (4 Credits)

#### Unit 1: Introduction to Cell Biology

- Overview of Prokaryotic and Eukaryotic Cells
- Cell Structure and Function
- Plasma Membrane and Transport Mechanisms
- Organelles and Their Functions
- Cytoskeleton and Cell Motility

#### Unit 2: Molecular Basis of Life

- Structure and Function of Biomolecules
- Nucleic Acids: DNA and RNA
- DNA Replication and Repair Mechanisms
- Transcription and RNA Processing
- Regulation of Gene Expression

**Unit 3: Protein Synthesis and Regulation**

- Genetic Code and Translation
- Post-Translational Modifications
- Protein Targeting and Degradation
- Molecular Chaperones and Protein Folding
- Epigenetic Modifications

**Unit 4: Cell Signaling and Communication**

- Receptors and Signal Transduction Pathways
- G-Protein Coupled Receptors
- Kinase Signaling and Secondary Messengers
- Cell Cycle Regulation and Apoptosis
- Cancer Biology and Oncogenes

**Unit 5: Applications of Cell and Molecular Biology**

- Recombinant DNA Technology
- CRISPR-Cas9 and Genome Editing
- Stem Cells and Regenerative Medicine
- Molecular Diagnostics and Therapeutics
- Future Trends in Cell and Molecular Biology

**Course Outcomes**

Upon successful completion of this course, students will be able to:

1. Interpret the relationship between cellular structure and function at both molecular and organismal levels
2. Apply molecular biology concepts to understand gene expression and regulation
3. Design and analyze experiments related to cellular and molecular processes
4. Evaluate scientific literature in cell and molecular biology
5. Integrate knowledge of cellular processes to solve complex biological problems

**Key Textbooks**

1. Alberts, B. et al. (2022). Molecular Biology of the Cell, 7th Edition. Garland Science
2. Lodish, H. et al. (2021). Molecular Cell Biology, 9th Edition. W.H. Freeman
3. Cooper, G.M. (2019). The Cell: A Molecular Approach, 8th Edition. Sinauer Associates

**Course Code: MBTT7502**

| L | T | P | C |
|---|---|---|---|
| 3 | 1 | 0 | 4 |

**Biochemistry and Metabolism**

**Credits: 4 | Contact Hours: 4**

**Course Description**

This course focuses on the chemistry of biological molecules, metabolic pathways, and cellular energetics. Students will study the structure and function of biomolecules, enzyme kinetics, and the integration of metabolic processes.

**Course Objectives**

1. Understand the structure and function of major biomolecules
2. Master the principles of enzyme kinetics and regulation
3. Analyze major metabolic pathways and their integration
4. Examine the role of hormones in metabolic regulation
5. Investigate cellular bioenergetics and energy transfer mechanisms

**Program Core – 2: Biochemistry and Metabolism (4 Credits)**

**Unit 1: Biomolecules and Their Interactions**

- Structure and Properties of Carbohydrates, Lipids, Proteins, and Nucleic Acids
- Enzymes: Classification, Kinetics, and Mechanisms
- Bioenergetics and Thermodynamics
- Vitamins and Coenzymes
- Metabolic Regulation

**Unit 2: Carbohydrate Metabolism**

- Glycolysis and Gluconeogenesis
- Citric Acid Cycle and Oxidative Phosphorylation
- Pentose Phosphate Pathway
- Glycogen Metabolism
- Disorders of Carbohydrate Metabolism

**Unit 3: Lipid and Protein Metabolism**

- Beta-Oxidation and Fatty Acid Synthesis
- Cholesterol and Lipoprotein Metabolism
- Protein Catabolism and Amino Acid Metabolism

- Urea Cycle and Nitrogen Balance
- Disorders of Lipid and Protein Metabolism

**Unit 4: Nucleic Acid and Hormonal Regulation**

- Purine and Pyrimidine Metabolism
- Hormones and Their Functions
- Endocrine Regulation of Metabolism
- Signal Transduction Pathways
- Metabolic Disorders (Diabetes, Obesity, etc.)

**Unit 5: Applied Biochemistry**

- Clinical Biochemistry and Biomarkers
- Nutritional Biochemistry
- Molecular Basis of Diseases
- Advances in Metabolic Engineering
- Biochemical Techniques and Instrumentation

**Course Outcomes**

Upon successful completion of this course, students will be able to:

1. Describe the relationship between molecular structure and biological function
2. Calculate and interpret enzyme kinetics parameters
3. Map and analyze metabolic pathways and their regulation
4. Evaluate the energetics of biochemical reactions
5. Apply biochemical principles to solve metabolic disorders

**Key Textbooks**

1. Nelson, D.L. and Cox, M.M. (2021). Lehninger Principles of Biochemistry, 8th Edition. W.H. Freeman
2. Berg, J.M. et al. (2019). Biochemistry, 9th Edition. W.H. Freeman
3. Voet, D. and Voet, J.G. (2021). Biochemistry, 5th Edition. Wiley

**Course Code: MBTT7503**

| L | T | P | C |
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| 3 | 1 | 0 | 4 |

**Microbiology and Immunology**

**Credits: 4 | Contact Hours: 4**

**Course Description**

This course covers fundamental concepts in microbiology and immunology, including microbial diversity, growth, and control, along with immune system components, functions, and responses to infection.

**Course Objectives**

1. Understand microbial diversity and classification systems
2. Analyze microbial growth, metabolism, and control methods
3. Examine host-pathogen interactions and disease mechanisms
4. Study immune system components and their functions
5. Investigate immune responses and immunological techniques

**Program Core – 3: Microbiology and Immunology (4 Credits)**

**Unit 1: Fundamentals of Microbiology**

- History and Scope of Microbiology
- Classification of Microorganisms
- Structure and Function of Bacteria, Viruses, Fungi, and Protozoa
- Microbial Growth and Cultivation
- Microbial Genetics and Evolution

**Unit 2: Microbial Pathogenesis and Control**

- Pathogenic Mechanisms and Virulence Factors
- Antibiotics and Mechanisms of Action
- Antibiotic Resistance and Public Health Concerns
- Sterilization and Disinfection
- Vaccines and Immunization

**Unit 3: Basics of Immunology**

- Innate and Adaptive Immunity
- Antigen and Antibody Structure and Function
- Complement System and Cytokines

- Immune Cell Signaling and Activation
- Major Histocompatibility Complex (MHC)

**Unit 4: Immunological Disorders and Applications**

- Hypersensitivity Reactions
- Autoimmune and Immunodeficiency Disorders
- Tumor Immunology
- Immunodiagnostic Techniques
- Therapeutic Monoclonal Antibodies

**Unit 5: Advances in Microbiology and Immunology**

- Microbiome and Human Health
- Emerging Infectious Diseases
- Bioterrorism and Biodefense
- Immunotherapy and Vaccines
- CRISPR and Microbial Genome Editing

**Course Outcomes**

Upon successful completion of this course, students will be able to:

1. Identify and classify microorganisms based on their characteristics
2. Apply methods for controlling microbial growth and spread
3. Evaluate immune system responses to various pathogens
4. Design immunological experiments and interpret results
5. Integrate microbiological and immunological concepts in disease prevention

**Key Textbooks**

1. Madigan, M.T. et al. (2022). Brock Biology of Microorganisms, 16th Edition. Pearson
2. Murphy, K. and Weaver, C. (2022). Janeway's Immunobiology, 10th Edition. Garland Science
3. Abbas, A.K. et al. (2021). Cellular and Molecular Immunology, 10th Edition. Elsevier

**Course Code: MBTT7504**

| L | T | P | C |
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| 3 | 1 | 0 | 4 |

**Techniques in Biotechnology – I**

**Credits: 4 | Contact Hours: 4**

**Course Description**

This course introduces fundamental techniques used in biotechnology research and industry, including molecular biology methods, protein analysis, and cell culture techniques.

**Course Objectives**

1. Master basic molecular biology techniques
2. Understand principles and applications of protein analysis methods
3. Learn cell culture and maintenance techniques
4. Examine nucleic acid manipulation and analysis methods
5. Study principles of genetic engineering and cloning

**Program Core – 4: Techniques in Biotechnology – I (4 Credits)**

**Unit 1: Basic Laboratory Techniques**

- Good Laboratory Practices (GLP)
- Microscopy Techniques
- pH and Buffers
- Spectroscopy (UV-Vis, Fluorescence, IR)
- Chromatography Basics

**Unit 2: Molecular Biology Techniques**

- DNA Extraction and Purification
- Polymerase Chain Reaction (PCR)
- Gel Electrophoresis (Agarose, SDS-PAGE)
- Cloning Vectors and Expression Systems
- Gene Sequencing Methods

**Unit 3: Protein and Enzyme Techniques**

- Protein Purification and Characterization
- Western Blotting
- Enzyme Assays and Kinetics
- Mass Spectrometry and Proteomics

- Structural Biology Techniques

**Unit 4: Immunological Techniques**

- ELISA and RIA
- Flow Cytometry
- Immunohistochemistry
- Hybridoma Technology
- Biosensors and Immunoassays

**Unit 5: Advanced Techniques and Applications**

- Nanotechnology in Biotechnology
- CRISPR and Genome Engineering
- Single-Cell Analysis
- Next-Generation Sequencing (NGS)
- High-Throughput Screening

**Course Outcomes**

Upon successful completion of this course, students will be able to:

1. Execute standard molecular biology protocols independently
2. Perform protein isolation, purification, and characterization
3. Maintain and manipulate cell cultures effectively
4. Design and implement cloning strategies
5. Troubleshoot common technical problems in biotechnology procedures

**Key Textbooks**

1. Green, M.R. and Sambrook, J. (2021). Molecular Cloning: A Laboratory Manual, 4th Edition. CSHL Press
2. Wilson, K. and Walker, J. (2018). Principles and Techniques of Biochemistry and Molecular Biology, 8th Edition. Cambridge University Press
3. Freshney, R.I. (2021). Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, 8th Edition. Wiley

**Course Code: MBTT7505**

| L | T | P | C |
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| 3 | 1 | 0 | 4 |

**Biostatistics and Bioinformatics**

**Credits: 4 | Contact Hours: 4**

**Course Description**

This course covers statistical methods for biological data analysis and computational approaches in bioinformatics, including sequence analysis, structural bioinformatics, and biological databases.

**Course Objectives**

1. Understand fundamental statistical concepts and their biological applications
2. Master bioinformatics tools and databases
3. Learn sequence analysis methods and algorithms
4. Study structural bioinformatics approaches
5. Examine data visualization and interpretation techniques

**Program Core – 5: Biostatistics and Bioinformatics (4 Credits)**

**Unit 1: Biostatistics Basics**

- Descriptive Statistics and Probability
- Inferential Statistics
- Hypothesis Testing
- Regression and Correlation
- Statistical Software Applications

**Unit 2: Computational Biology**

- Biological Databases
- Sequence Alignment and Phylogenetics
- Genomic Data Analysis
- Structural Bioinformatics
- Machine Learning in Bioinformatics

**Unit 3: Omics Technologies**

- Genomics, Transcriptomics, and Proteomics
- Metabolomics and Systems Biology

- High-Throughput Data Analysis
- Biomarker Discovery
- Personalized Medicine

**Unit 4: Applications in Biomedical Sciences**

- Drug Discovery and Development
- Epidemiological Studies
- Bioinformatics in Cancer Research
- Artificial Intelligence in Healthcare
- Predictive Modeling in Biology

**Unit 5: Advanced Tools and Techniques**

- R and Python for Bioinformatics
- Network Biology
- Big Data in Life Sciences
- Biostatistics in Clinical Trials
- Ethical Considerations in Bioinformatics

**Course Outcomes**

Upon successful completion of this course, students will be able to:

1. Apply appropriate statistical methods to analyze biological data
2. Use bioinformatics tools and databases effectively
3. Perform sequence analysis and interpretation
4. Analyze protein structure and function using computational tools
5. Create meaningful visualizations of biological data

**Key Textbooks**

1. Whitlock, M.C. and Schluter, D. (2020). The Analysis of Biological Data, 3rd Edition. W.H. Freeman
2. Pevsner, J. (2023). Bioinformatics and Functional Genomics, 4th Edition. Wiley-Blackwell
3. Mount, D.W. (2022). Bioinformatics: Sequence and Genome Analysis, 4th Edition. CSHL Press

**Laboratory Courses**

**Lab-1: Techniques in Cell Biology and Biochemistry Lab**

**Credits: 2 | Contact Hours: 4**

**Course Description**

Hands-on laboratory course focusing on essential techniques in cell biology and biochemistry, including cell culture, protein analysis, enzyme assays, and cellular imaging.

**Course Objectives**

1. Develop practical skills in cell culture techniques
2. Master protein isolation and characterization methods
3. Perform enzyme kinetics studies
4. Learn microscopy and cell imaging techniques
5. Understand laboratory safety and good laboratory practices

**List of Experiments**

**Cell Biology Experiments**

1. **Microscopy and Cell Staining** – Observation of prokaryotic and eukaryotic cells using light microscopy; simple and differential staining (Gram staining, Wright's staining).
2. **Cell Fractionation and Organelle Isolation** – Separation of cellular components using differential centrifugation.
3. **Hemocytometry and Cell Counting** – Use of a hemocytometer to count cells and determine viability using Trypan Blue staining.
4. **Cell Culture Techniques** – Introduction to aseptic techniques, cell seeding, and maintenance of adherent/suspension cell cultures.
5. **Mitosis and Meiosis Observation** – Study of cell division stages using onion root tip and prepared slides.
6. **Fluorescence Microscopy** – Observation of cellular structures using fluorescence-labeled dyes (e.g., DAPI for nuclei).
7. **Apoptosis Assay** – Detection of programmed cell death using Annexin V/Propidium Iodide staining.

**Biochemistry Experiments**

8. **pH and Buffer Preparation** – Preparation and titration of buffers to understand pH stability in biological systems.
9. **Protein Estimation by Bradford/Lowry Assay** – Quantification of proteins using spectrophotometry.

10. **Carbohydrate Estimation by Anthrone/Selivanoff's Test** – Detection and quantification of sugars.

11. **Enzyme Kinetics (Amylase/Catalase Activity)** – Study of enzyme action, effect of substrate concentration, pH, and temperature on enzyme activity.

12. **Chromatography Techniques** – Separation of biomolecules using paper chromatography (amino acids) and thin-layer chromatography (lipids).

13. **Electrophoresis of Proteins and Nucleic Acids** – SDS-PAGE for protein separation and agarose gel electrophoresis for DNA/RNA analysis.

14. **Spectrophotometric Analysis of DNA/RNA** – Estimation of nucleic acids using UV absorbance (A260/A280 ratio).

**Course Outcomes**

Upon successful completion of this course, students will be able to:

1. Maintain cell cultures and assess cell viability
2. Execute protein isolation and quantification protocols
3. Analyze enzyme kinetics and interpret results
4. Perform microscopy and document cellular structures
5. Apply safe laboratory practices and maintain proper documentation

**Key Textbooks**

1. Barker, K. (2018). At the Bench: A Laboratory Navigator, 2nd Edition. CSHL Press
2. Carter, G.W. (2020). Essential Laboratory Techniques for Biochemistry and Molecular Biology. Springer
3. Davis, J.M. (2021). Basic Cell Culture: A Practical Approach, 3rd Edition. Oxford University Press

**Lab-2: Microbiology and Immunology Lab**

**Credits: 2 | Contact Hours: 4**

**Course Description**

Practical laboratory course covering basic microbiological techniques and immunological methods, including bacterial culture, identification, and immunological assays.

**Course Objectives**

1. Master aseptic techniques and microbial culture methods
2. Learn microbial identification techniques
3. Perform immunological assays
4. Understand antimicrobial susceptibility testing
5. Develop skills in serological techniques

**Microbiology Experiments:**

1. **Sterilization Techniques** – Methods such as autoclaving, filtration, and dry heat sterilization.
2. **Preparation of Culture Media** – Nutrient agar, MacConkey agar, and other selective/differential media.
3. **Aseptic Techniques & Streak Plate Method** – Isolation of pure bacterial colonies.
4. **Gram Staining & Microscopic Examination** – Differentiation between Gram-positive and Gram-negative bacteria.
5. **Acid-Fast Staining (Ziehl-Neelsen Staining)** – Identification of Mycobacterium species.
6. **Motility Testing** – Hanging drop method and semi-solid media for detecting bacterial motility.
7. **Biochemical Characterization of Bacteria** – IMViC tests (Indole, Methyl Red, Voges-Proskauer, Citrate utilization).
8. **Antibiotic Sensitivity Testing (Kirby-Bauer Method)** – Determining antibiotic resistance patterns.
9. **Bacterial Growth Curve (Spectrophotometric Analysis)** – Understanding bacterial growth phases.
10. **Identification of Fungi using Lactophenol Cotton Blue Staining** – Morphological examination of fungal species.

**Immunology Experiments:**

11. **Blood Grouping by Agglutination Reaction** – Determining ABO and Rh blood groups.
12. **Widal Test for Typhoid Fever** – Slide and tube agglutination test for Salmonella.

13. **ELISA (Enzyme-Linked Immunosorbent Assay)** – Detection of specific antibodies or antigens.

14. **Ouchterlony Double Diffusion (Precipitation Reaction)** – Study of antigen-antibody interactions.

15. **Latex Agglutination Test for C-Reactive Protein (CRP)** – Detection of inflammatory markers

**Course Outcomes**

Upon successful completion of this course, students will be able to:

1. Execute aseptic techniques and maintain sterile conditions
2. Identify microorganisms using various methods
3. Perform and interpret immunological assays
4. Conduct antimicrobial susceptibility tests
5. Apply serological techniques for disease diagnosis

**Key Textbooks**

1. Cappuccino, J.G. and Welsh, C. (2024). Microbiology: A Laboratory Manual, 13th Edition. Pearson

2. Goldman, E. and Green, L.H. (2021). Practical Handbook of Microbiology, 4th Edition. CRC Press

3. Detrick, B. et al. (2020). Manual of Molecular and Clinical Laboratory Immunology, 8th Edition. ASM Press

**Course Code: MBTT7506**

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## Genetic Engineering and Recombinant DNA Technology

**Course Description:**

This course provides an in-depth understanding of the principles and techniques of genetic engineering and recombinant DNA technology. It covers fundamental concepts, tools, and applications in the field of molecular biology and biotechnology.

**Course Objectives:**

1. To introduce the basic principles of genetic engineering and recombinant DNA technology.
2. To familiarize students with molecular cloning strategies and gene expression techniques.
3. To explore various genome editing tools such as CRISPR-Cas9.
4. To understand ethical, legal, and biosafety concerns in genetic engineering.
5. To discuss real-world applications in medicine, agriculture, and industry.

**Syllabus:**

**Unit I: Introduction to Genetic Engineering**

- Basics of genes and genomes
- DNA structure and function
- Principles of recombinant DNA technology
- Tools and enzymes in genetic engineering
- Vectors in genetic engineering

**Unit II: Gene Cloning and Expression**

- Cloning strategies and techniques
- Selection and screening methods
- Expression vectors and host systems
- Gene libraries (Genomic and cDNA)
- Recombinant protein expression and purification

**Unit III: Advanced Genome Editing Techniques**

- CRISPR-Cas9 technology
- TALENs and ZFNs
- Gene silencing and RNA interference
- Genome sequencing techniques
- Synthetic biology and its applications

**Unit IV: Applications of Genetic Engineering**

- Gene therapy and regenerative medicine
- Transgenic plants and animals
- Biopharmaceuticals and industrial enzymes
- Vaccines and monoclonal antibodies
- Forensic and diagnostic applications

**Unit V: Ethical, Legal, and Biosafety Issues**

- Ethical implications of genetic modifications
- Regulations and guidelines for genetic engineering
- Biosafety concerns in recombinant technology
- Intellectual property rights and patents
- Future prospects of genetic engineering

**Learning Outcomes:**

1. Explain fundamental concepts of genetic engineering and recombinant DNA technology.
2. Demonstrate molecular cloning and gene expression techniques.
3. Analyze genome editing technologies and their applications.
4. Evaluate the ethical and biosafety issues related to genetic engineering.
5. Apply genetic engineering knowledge to biotechnological applications.

**Textbooks:**

1. Primrose, S. B., & Twyman, R. M. (2013). Principles of Gene Manipulation and Genomics. Blackwell Publishing.
2. Brown, T. A. (2016). Gene Cloning and DNA Analysis: An Introduction. Wiley-Blackwell.
3. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2013). Molecular Biology of the Gene. Pearson.
4. Nicholl, D. S. T. (2008). An Introduction to Genetic Engineering. Cambridge University Press.
5. Glick, B. R., & Patten, C. L. (2017). Molecular Biotechnology: Principles and Applications of Recombinant DNA. ASM Press.

**Course Code: MBTT7507**

| L | T | P | C |
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| 3 | 1 | 0 | 4 |

## Molecular Diagnostics

**Course Description:**

This course explores the principles and applications of molecular diagnostics in medical and clinical settings. It covers diagnostic techniques based on nucleic acids and proteins, providing insights into modern diagnostic tools and their relevance in disease detection and management.

**Course Objectives:**

1. To understand the fundamentals of molecular diagnostics.
2. To explore various techniques for detecting nucleic acids and proteins.
3. To study the applications of molecular diagnostics in infectious diseases and genetic disorders.
4. To analyze quality control and regulatory aspects of molecular diagnostics.
5. To discuss recent advances and future trends in molecular diagnostics.

**Syllabus:**

**Unit I: Fundamentals of Molecular Diagnostics**

- Introduction to molecular diagnostics
- Biomarkers and their significance
- Nucleic acids and protein-based detection methods
- Principles of PCR and its variants
- Role of molecular diagnostics in healthcare

**Unit II: Techniques in Molecular Diagnostics**

- Polymerase Chain Reaction (PCR) and Real-Time PCR
- DNA sequencing and Next-Generation Sequencing (NGS)
- Microarrays and hybridization techniques
- Immunoassays and ELISA
- Biosensors and point-of-care diagnostics

**Unit III: Applications in Disease Diagnosis**

- Infectious disease diagnostics
- Genetic and hereditary disorders
- Cancer diagnostics and liquid biopsy
- Pharmacogenomics and personalized medicine
- Forensic and environmental applications

**Unit IV: Quality Control and Regulatory Aspects**

- Standardization of molecular diagnostic tests
- Good laboratory practices and accreditation
- Regulatory guidelines (FDA, ISO, CLIA)
- Validation and verification of diagnostic assays
- Ethical considerations in molecular diagnostics

**Unit V: Advances and Future Prospects**

- CRISPR-based diagnostics
- AI and machine learning in diagnostics
- Wearable biosensors and real-time monitoring
- Nanotechnology in diagnostics
- Emerging trends in precision medicine

**Learning Outcomes:**

1. Understand the principles and methodologies of molecular diagnostics.
2. Perform and interpret diagnostic techniques based on nucleic acids and proteins.
3. Apply molecular diagnostic tools for disease identification and monitoring.
4. Assess the regulatory and quality control aspects of molecular diagnostics.
5. Evaluate emerging technologies in molecular diagnostics.

**Textbooks:**

1. Willey, J. M., Sandman, K., & Wood, D. (2017). Prescott's Microbiology. McGraw-Hill.
2. Strachan, T., & Read, A. P. (2011). Human Molecular Genetics. Garland Science.
3. Murphy, K. (2016). Molecular Diagnostics: Fundamentals, Methods, and Clinical Applications. Wolters Kluwer.
4. Guttmacher, A. E., Collins, F. S., & Carmichael, C. (2019). Principles of Genomic Medicine. Springer.
5. Jain, K. K. (2017). Molecular Diagnostics: Technologies and Applications. Springer.

**Course Code: MBTT7508**

| L | T | P | C |
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| 3 | 1 | 0 | 4 |

## Bioprocess Engineering and Fermentation Technology

**Course Description:**

This course focuses on the principles and applications of bioprocess engineering and fermentation technology. It provides insights into microbial growth kinetics, bioreactor design, fermentation processes, and industrial applications of biotechnology.

**Course Objectives:**

1. To understand the principles of bioprocess engineering and fermentation.
2. To explore microbial growth kinetics and bioreactor operations.
3. To study downstream processing and product recovery.
4. To analyze industrial fermentation processes.
5. To discuss advancements and future trends in bioprocessing.

**Syllabus:**

**Unit I: Fundamentals of Bioprocess Engineering**

- Introduction to bioprocess engineering
- Microbial cell growth and metabolism
- Sterilization of bioreactors and media
- Enzyme kinetics and biocatalysis
- Strain improvement techniques

**Unit II: Bioreactor Design and Operation**

- Types of bioreactors and their components
- Aeration and agitation in bioreactors
- Scale-up and scale-down strategies
- Bioprocess monitoring and control
- Computational modeling in bioprocess engineering

**Unit III: Fermentation Technology**

- Batch, fed-batch, and continuous fermentation
- Microbial, plant, and animal cell cultures
- Submerged and solid-state fermentation
- Production of antibiotics, enzymes, and biofuels
- Fermentation economics and sustainability

**Unit IV: Downstream Processing**

- Cell disruption and product recovery

- Purification techniques (filtration, chromatography)
- Product formulation and stability
- Bioproduct quality control and regulatory aspects
- Industrial case studies in bioprocessing

**Unit V: Advances and Applications in Bioprocess Engineering**

- Bioprocessing in pharmaceutical industries
- Bioremediation and waste management
- Tissue engineering and biomanufacturing
- Synthetic biology in bioprocessing
- Future trends in bioprocess engineering

**Learning Outcomes:**

1. Explain the principles and applications of bioprocess engineering.
2. Analyze microbial growth kinetics and fermentation processes.
3. Demonstrate knowledge of bioreactor design and operation.
4. Evaluate downstream processing techniques and product recovery.
5. Assess industrial applications and advancements in bioprocessing.

**Textbooks:**

1. Shuler, M. L., & Kargi, F. (2017). Bioprocess Engineering: Basic Concepts. Pearson.
2. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2017). Principles of Fermentation Technology. Elsevier.
3. Doran, P. M. (2012). Bioprocess Engineering Principles. Academic Press.
4. Nielsen, J., Villadsen, J., & Liden, G. (2017). Bioreaction Engineering Principles. Springer.
5. Crueger, W., & Crueger, A. (2017). Biotechnology: A Textbook of Industrial Microbiology. Panima Publishing.

**Course Code: MBTT7509**

| L | T | P | C |
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| 3 | 1 | 0 | 4 |

## Techniques in Biotechnology – II

**Course Description:**

This course provides advanced insights into key laboratory techniques in biotechnology, focusing on molecular, biochemical, and analytical methods used in research and industry.

**Course Objectives:**

1. To explore advanced molecular biology and biochemical techniques.
2. To understand spectroscopic and chromatographic methods.
3. To familiarize students with bioinformatics tools and applications.
4. To study cell culture and imaging techniques.
5. To develop proficiency in data analysis and interpretation.

**Syllabus:**

**Unit I: Advanced Molecular Techniques**

- Site-directed mutagenesis
- Southern, Northern, and Western blotting
- Chromatin immunoprecipitation (ChIP)
- RNA sequencing and transcriptomics
- Gene expression analysis

**Unit II: Biochemical and Analytical Techniques**

- Chromatographic techniques (HPLC, FPLC, GC)
- Spectroscopy (UV-Vis, NMR, Mass Spectrometry)
- Centrifugation and ultracentrifugation
- Electrophoresis and microfluidics
- Enzyme assays and kinetics

**Unit III: Cell Culture and Imaging Techniques**

- Mammalian and microbial cell culture
- Fluorescence and confocal microscopy
- Flow cytometry and cell sorting
- Live-cell imaging
- High-content screening

**Unit IV: Bioinformatics and Computational Tools**

- Sequence alignment and phylogenetics
- Structural bioinformatics and molecular docking

- Systems biology and omics data analysis
- Machine learning applications in biotechnology
- Databases and software tools in bioinformatics

**Unit V: Emerging Trends in Biotechnology Techniques**

- Lab-on-a-chip technologies
- CRISPR and genome-wide screening
- Nanobiotechnology applications
- Single-cell analysis techniques
- Automation and robotics in biotechnology

**Learning Outcomes:**

1. Demonstrate proficiency in advanced molecular and biochemical techniques.
2. Apply chromatographic and spectroscopic methods for analysis.
3. Utilize bioinformatics tools for data interpretation.
4. Perform cell culture and imaging techniques in research.
5. Evaluate emerging biotechnological techniques and their applications.

**Textbooks:**

1. Wilson, K., & Walker, J. (2018). Principles and Techniques of Biochemistry and Molecular Biology. Cambridge University Press.
2. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2015). Molecular Biology of the Cell. Garland Science.
3. Sambrook, J., & Russell, D. W. (2001). Molecular Cloning: A Laboratory Manual. Cold Spring Harbor Laboratory Press.
4. Mount, D. W. (2004). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.
5. Voet, D., & Voet, J. G. (2016). Biochemistry. Wiley.

**Course Code: MBTT7510**

| L | T | P | C |
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| 3 | 1 | 0 | 4 |

## Genomics and Proteomics

**Course Description:**

This course provides an in-depth understanding of the principles, technologies, and applications of genomics and proteomics. It covers genome organization, sequencing technologies, functional genomics, transcriptomics, and proteomics with an emphasis on their role in biomedical research and personalized medicine.

**Course Objectives:**

1. To introduce the fundamental concepts of genomics and proteomics.
2. To explore genome sequencing technologies and their applications.
3. To understand functional genomics and transcriptomics.
4. To examine protein structure, function, and proteomics techniques.
5. To apply genomics and proteomics in clinical and biomedical research.

**Syllabus:**

**Unit 1: Basics of Genomics**

- Introduction to Genomes: Prokaryotic vs. Eukaryotic Genomes
- Genome Organization: Coding and Non-Coding DNA
- DNA Sequencing Technologies: Sanger, NGS, and Third-Generation Sequencing
- Genome Mapping and Annotation
- Comparative Genomics

**Unit 2: Functional Genomics and Transcriptomics**

- Gene Expression Analysis: Microarrays and RNA Sequencing
- Epigenetics: DNA Methylation and Histone Modifications
- Non-Coding RNAs and Their Functions
- Genome Editing Techniques: CRISPR-Cas9, TALENs, and ZFNs
- Applications of Functional Genomics in Disease Research

**Unit 3: Basics of Proteomics**

- Introduction to Proteins: Structure and Function
- Protein-Protein Interactions and Networks
- Proteomics Techniques: 2D Gel Electrophoresis, Mass Spectrometry
- Protein Identification and Quantification
- Post-Translational Modifications

**Unit 4: Advanced Proteomics Techniques and Applications**

- Structural Proteomics: X-ray Crystallography, NMR, Cryo-EM
- Functional Proteomics and Interactomics
- Proteogenomics and Personalized Medicine
- Biomarker Discovery and Drug Target Identification
- Application of Proteomics in Clinical and Pharmaceutical Research

**Unit 5: Integrative Genomics and Proteomics Approaches**

- Systems Biology: Multi-Omics Data Integration
- Computational Biology and Bioinformatics in Genomics and Proteomics
- Artificial Intelligence and Machine Learning in Omics Research
- Challenges and Ethical Considerations in Genomics and Proteomics
- Future Directions in Precision Medicine

**Learning Outcomes:**

1. Understand the organization and sequencing of genomes.
2. Analyze gene expression and epigenetic modifications.
3. Apply proteomics techniques for protein analysis.
4. Evaluate integrative omics approaches in biomedical sciences.
5. Explore emerging technologies in genomics and proteomics.

**Textbooks:**

1. Primrose, S. B., & Twyman, R. M. (2013). Principles of Gene Manipulation and Genomics. Wiley.
2. Brown, T. A. (2020). Genomes 4. Garland Science.
3. Mount, D. W. (2004). Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.
4. Liebler, D. C. (2002). Introduction to Proteomics: Tools for the New Biology. Humana Press.
5. Westermeier, R., & Naven, T. (2007). Proteomics in Practice: A Laboratory Manual of Proteome Analysis. Wiley.

**Lab Course 3: Genetic Engineering Lab (2 Credits)**

**List of Experiments:**

1. Isolation of Genomic DNA from Bacteria and Eukaryotic Cells
2. Plasmid DNA Isolation and Purification
3. Restriction Digestion and Ligation of DNA
4. PCR Amplification and Optimization
5. Agarose Gel Electrophoresis and DNA Visualization
6. Cloning of DNA into Expression Vectors
7. Transformation and Screening of Recombinant Clones
8. Southern Blotting Technique
9. RNA Extraction and Quantification
10. cDNA Synthesis and RT-PCR
11. CRISPR-Cas9 Gene Editing Basics
12. Site-Directed Mutagenesis
13. Recombinant Protein Expression in Bacteria
14. SDS-PAGE for Protein Analysis
15. Western Blotting and Immunodetection

**Lab Course 4: Molecular Diagnostics Lab (2 Credits)**

**List of Experiments:**

1. Blood Sample Collection and DNA Extraction
2. Spectrophotometric Analysis of Nucleic Acids
3. PCR-based Diagnosis of Genetic Disorders
4. RFLP for Disease Mutation Detection
5. Real-Time PCR (qPCR) for Pathogen Detection
6. ELISA for Antigen and Antibody Detection
7. Immunofluorescence Assay
8. Karyotyping for Chromosomal Abnormalities
9. Microarray-Based Gene Expression Profiling
10. Next-Generation Sequencing (NGS) Data Analysis
11. Multiplex PCR for Infectious Disease Diagnosis
12. DNA Fingerprinting for Forensic Applications
13. Western Blotting for Protein Biomarkers
14. Biosensors for Disease Detection
15. Bioinformatics in Molecular Diagnostics

**Course Code: MBTT8511**

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## Stem Cell Biology and Regenerative Medicine

**Course Description:**

This course explores the fundamental principles of stem cell biology and their applications in regenerative medicine. It covers stem cell types, mechanisms of differentiation, and their potential in disease treatment and tissue engineering.

**Course Objectives:**

1. Understand the biology and classification of stem cells.
2. Explore molecular mechanisms governing stem cell differentiation and self-renewal.
3. Examine stem cell-based regenerative therapies and their clinical applications.
4. Discuss ethical, regulatory, and translational challenges in stem cell research.
5. Analyze recent advancements in stem cell engineering and therapeutic applications.

**Syllabus:**

**Unit 1: Introduction to Stem Cells**

- Definition and historical perspective
- Types of stem cells: embryonic, adult, induced pluripotent, and cancer stem cells
- Stem cell niches and their significance

**Unit 2: Stem Cell Biology**

- Mechanisms of self-renewal and differentiation
- Signaling pathways in stem cell regulation
- Stem cell culture techniques and characterization

**Unit 3: Regenerative Medicine and Tissue Engineering**

- Stem cell therapy for neurodegenerative diseases, cardiovascular diseases, and diabetes
- 3D bioprinting and organoid technology
- Gene editing technologies in regenerative medicine

**Unit 4: Clinical Applications and Challenges**

- Current clinical trials and FDA-approved therapies
- Ethical and regulatory considerations
- Personalized medicine approaches using stem cells

**Unit 5: Advances in Stem Cell Technology**

- CRISPR/Cas9 in stem cell modification
- Artificial and synthetic biology approaches
- Future perspectives in regenerative medicine

**Learning Outcomes:**

1. Describe the types and functions of stem cells in health and disease.
2. Explain the mechanisms governing stem cell differentiation.
3. Evaluate the potential of stem cells in clinical applications.
4. Critically analyze the ethical considerations in stem cell research.
5. Assess emerging trends and future directions in regenerative medicine.

**Recommended Textbooks:**


1. "Essentials of Stem Cell Biology" - Robert Lanza, Elsevier, 2021.
2. "Stem Cells: From Biology to Therapy" - Robert A. Meyers, Wiley, 2018.
3. "Principles of Regenerative Medicine" - Anthony Atala, Elsevier, 2019.
4. "Stem Cells Handbook" - Stewart Sell, Springer, 2019.
5. "Regenerative Medicine: From Protocol to Patient" - Gustav Steinhoff, Springer, 2020.

**Course Code: MBTT8512**

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# Vaccine Technology

**Course Description:**

This course provides comprehensive knowledge about vaccine development, including traditional and modern vaccine platforms, immunological principles, production techniques, regulatory aspects, and emerging vaccine technologies.

**Course Objectives:**

1. Understand the principles of immunology relevant to vaccine development.
2. Study different vaccine types, their production, and quality control.
3. Analyze the role of adjuvants and delivery systems in vaccine efficacy.
4. Discuss regulatory frameworks and challenges in vaccine approval.
5. Examine innovations in vaccine technologies and their applications.

**Syllabus:**

**Unit 1: Fundamentals of Vaccinology**

- History and importance of vaccines
- Immune response to vaccination
- Types of immunity: active and passive

**Unit 2: Vaccine Types and Production**

- Live attenuated, inactivated, subunit, conjugate, and toxoid vaccines
- mRNA and viral vector-based vaccines
- Large-scale production and quality control measures

**Unit 3: Adjuvants and Delivery Systems**

- Mechanisms of action of adjuvants
- Liposomes, nanoparticles, and novel delivery strategies
- Cold chain and storage requirements

**Unit 4: Regulatory and Safety Aspects**

- WHO and FDA guidelines for vaccine approval
- Clinical trial phases for vaccine development
- Vaccine hesitancy and public health policies

**Unit 5: Emerging Trends in Vaccine Development**

- Reverse vaccinology and computational vaccine design
- Cancer and therapeutic vaccines
- Global impact of emerging infectious diseases and pandemic preparedness

**Learning Outcomes:**

1. Explain immunological concepts related to vaccines.
2. Compare various vaccine types and their applications.
3. Analyze adjuvants and delivery mechanisms for vaccines.
4. Evaluate the regulatory and ethical aspects of vaccine development.
5. Assess innovations and emerging trends in vaccine technology.

**Recommended Textbooks:**

1. "Vaccinology: Principles and Practice" - A. M. S. McLean, Wiley, 2019.
2. "Plotkin's Vaccines" - Stanley Plotkin, Elsevier, 2021.
3. "Vaccine Design: Methods and Protocols" - Sunil Thomas, Springer, 2018.
4. "Modern Vaccine Development" - Larry R. Goodridge, Springer, 2021.
5. "The Vaccine Book" - Barry Bloom, Elsevier, 2020.

**Course Code: MBTT8513**

| L | T | P | C |
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| 3 | 1 | 0 | 4 |

**Pharmacogenomics and Personalized Medicine**

**Course Description:**

This course introduces students to the principles of pharmacogenomics and personalized medicine, focusing on genetic influences on drug response, biomarker discovery, and precision medicine approaches for disease treatment.

**Course Objectives:**

1. Understand the genetic basis of drug response variability.
2. Explore genomic technologies for biomarker discovery.
3. Analyze ethical and regulatory aspects of pharmacogenomics.
4. Discuss personalized therapeutic strategies in clinical practice.
5. Examine advances in gene-based drug development.

**Syllabus:**

**Unit 1: Basics of Pharmacogenomics**

- Introduction to pharmacogenetics and pharmacogenomics
- Genetic polymorphisms and drug metabolism
- Pharmacogenomic databases and resources

**Unit 2: Genomic Technologies in Medicine**

- Next-generation sequencing and microarrays
- Bioinformatics tools for pharmacogenomics
- Role of epigenetics in drug response

**Unit 3: Applications in Disease Treatment**

- Personalized medicine in oncology
- Pharmacogenomics in cardiovascular diseases
- Gene therapy approaches

**Unit 4: Regulatory and Ethical Considerations**

- FDA guidelines for pharmacogenomics
- Ethical implications of genetic testing
- Data privacy and genomic medicine

**Unit 5: Future Trends in Pharmacogenomics**

- AI and machine learning in personalized medicine

- CRISPR-based therapies
- Global impact of precision medicine

**Learning Outcomes:**

1. Explain genetic factors influencing drug response.
2. Utilize genomic tools for personalized therapy.
3. Assess ethical considerations in pharmacogenomics.
4. Analyze case studies in precision medicine.
5. Discuss innovations in targeted drug development.

**Recommended Textbooks:**

1. "Principles of Pharmacogenomics" - Russ B. Altman, Springer, 2021.
2. "Pharmacogenomics in Precision Medicine" - Weimin Cai, Elsevier, 2020.
3. "Personalized Medicine: Concepts and Applications" - Rongling Wu, Wiley, 2019.
4. "Clinical Pharmacogenomics" - Werner Kalow, Springer, 2018.
5. "Handbook of Pharmacogenomics" - Sandosh Padmanabhan, Springer, 2019.

**Course Code: MBTT8514**

| L | T | P | C |
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| 3 | 1 | 0 | 4 |

## Medical Biotechnology Applications

**Course Description:**

This course covers advanced applications of biotechnology in medicine, including diagnostics, therapeutics, biomedical devices, and gene therapy. It emphasizes translational research and commercialization aspects.

**Course Objectives:**

1. Understand key biotechnological innovations in medicine.
2. Explore molecular diagnostics and biosensors.
3. Analyze gene therapy and recombinant protein production.
4. Evaluate biomedical devices and nanotechnology applications.
5. Discuss regulatory and ethical aspects of medical biotechnology.

**Syllabus:**

**Unit 1: Introduction to Medical Biotechnology**

- Scope and applications
- Role of biotechnology in disease management
- Biopharmaceuticals and personalized medicine

**Unit 2: Molecular Diagnostics and Imaging**

- PCR, microarrays, and next-generation sequencing
- CRISPR-based diagnostics
- Biosensors and medical imaging technologies

**Unit 3: Gene Therapy and Cell-based Therapies**

- Gene editing technologies and viral vectors
- Stem cell therapy and regenerative medicine
- Immunotherapy and CAR-T cell therapy

**Unit 4: Biomedical Devices and Nanotechnology**

- Biomaterials and tissue engineering
- Drug delivery systems and nanomedicine
- Smart biosensors and wearable health technologies

**Unit 5: Regulations and Future Perspectives**

- FDA and EMA guidelines for medical biotechnology

- Bioethics and patient safety
- Emerging trends: AI in biotechnology and synthetic biology

**Learning Outcomes:**

1. Describe major biotechnological applications in medicine.
2. Apply molecular diagnostic techniques in disease detection.
3. Evaluate gene therapy and regenerative medicine strategies.
4. Analyze the role of biomedical devices and nanotechnology.
5. Assess regulatory and ethical considerations in medical biotechnology.

**Recommended Textbooks:**

1. "Medical Biotechnology" - Bernard R. Glick, ASM Press, 2020.
2. "Biotechnology and Biopharmaceuticals" - Rodney Ho, Wiley, 2018.
3. "Biomedical Nanotechnology" - Neelina Malsch, CRC Press, 2019.
4. "Gene Therapy: Methods and Protocols" - Clévio Nóbrega, Springer, 2021.
5. "Regenerative Medicine and Biomaterials" - Roger Narayan, Elsevier, 2020

**Lab 5: Stem Cell and Immunotherapy Lab (2 Credits, 4 Hours)**

1. Isolation and Culture of Mesenchymal Stem Cells from Bone Marrow
2. Characterization of Stem Cells Using Flow Cytometry
3. Differentiation of Stem Cells into Neuronal and Adipogenic Lineages
4. Assessment of Stem Cell Viability and Proliferation Using MTT Assay
5. CRISPR/Cas9-Based Gene Editing in Stem Cells
6. Co-culture Techniques for Stem Cell-Based Immunotherapy
7. Generation of Induced Pluripotent Stem Cells (iPSCs) from Fibroblasts
8. Detection of Stem Cell Surface Markers Using Immunocytochemistry
9. 3D Bioprinting of Stem Cells for Tissue Engineering
10. Stem Cell-Based Cytotoxicity Assay for Drug Screening
11. In Vitro Expansion of Natural Killer (NK) Cells for Immunotherapy
12. T-Cell Isolation and Expansion for CAR-T Therapy Applications
13. Enzyme-Linked Immunosorbent Assay (ELISA) for Cytokine Profiling
14. Evaluation of Antibody-Dependent Cellular Cytotoxicity (ADCC)
15. Immunophenotyping of Stem Cells Using Fluorescent Microscopy

**Lab 6: Pharmacogenomics Lab (2 Credits, 4 Hours)**

1. Extraction and Quantification of Genomic DNA from Blood Samples
2. Polymerase Chain Reaction (PCR) for Genotyping Drug Metabolizing Genes
3. Real-Time PCR for Pharmacogenomic Biomarker Analysis
4. SNP Analysis Using Microarray Technology
5. Next-Generation Sequencing (NGS) for Pharmacogenomic Applications
6. Bioinformatics Tools for Pharmacogenomics Data Analysis
7. Drug-Response Prediction Using Pharmacogenomic Databases
8. In Silico Docking Studies for Drug-Target Interactions
9. Cytochrome P450 Enzyme Activity Assay
10. Functional Analysis of Genetic Variants Using Reporter Assays
11. RNA Sequencing for Transcriptome-Based Drug Response Profiling
12. Epigenetic Modifications and Their Role in Drug Response
13. Pharmacokinetics and Pharmacodynamics Modeling in Personalized Medicine
14. Genotyping and Allele Frequency Analysis of Pharmacogenes in Populations
15. Ethical Considerations and Case Studies in Pharmacogenomics

PROGRAMME ELECTIVES – 1

| | |
|---|---|
| **Program Elective - 1**<br>3 Credits & 3 Credit Hours | Biopharmaceutical Process Development (MBTT8601A) |
| | CRISPR and Genome Editing Technologies (MBTT8601B) |
| | RNA Therapeutics and mRNA Vaccines (MBTT8601C) |
| | Molecular Oncology and Cancer Therapeutics (MBTT8601D) |
| | Regulatory Affairs in Biologics and Biosimilars (MBTT8601E) |

## 1. Biopharmaceutical Process Development

**Course Description:**

This course covers the principles and practices involved in the development of biopharmaceutical products, including protein-based therapeutics, monoclonal antibodies, and vaccines. Emphasis will be placed on the bioprocess design, scale-up, purification, and regulatory considerations during the development of biopharmaceuticals.

**Course Objectives:**

1. Understand the principles of biopharmaceutical product development.
2. Explore different methods of recombinant protein expression and production.
3. Study the purification processes and formulation of biopharmaceuticals.
4. Gain knowledge of the regulatory aspects of biopharmaceutical manufacturing.
5. Investigate the challenges in scaling up bioprocesses for commercial production.

**Syllabus:**

**Unit 1: Introduction to Biopharmaceuticals**

1. Overview of Biopharmaceuticals
2. Types of Biopharmaceutical Products
3. Biotech vs. Traditional Pharmaceuticals
4. Regulatory Landscape in Biopharmaceutical Development
5. Key Challenges in Biopharmaceutical Production

**Unit 2: Recombinant Protein Expression and Production**

1. Basics of Genetic Engineering
2. Selection of Host Organisms (E. coli, CHO cells, etc.)
3. Expression Vectors and Plasmid Design
4. Fermentation and Cultivation Techniques
5. Strategies for Enhancing Protein Yield

**Unit 3: Downstream Processing and Purification**

1. Techniques in Cell Harvesting and Clarification
2. Chromatography Methods (Affinity, Ion Exchange, etc.)
3. Filtration and Ultrafiltration Methods
4. Concentration and Formulation
5. Quality Control and Assurance in Purification

**Unit 4: Scale-Up and Process Optimization**

1. Challenges in Scale-Up of Bioprocesses
2. Bioreactor Design and Operation

3. Process Monitoring and Control
4. Optimization of Yield and Productivity
5. Case Studies in Successful Biopharmaceutical Scale-Up

**Unit 5: Regulatory and Commercial Aspects of Biopharmaceuticals**

1. Regulatory Framework for Biologics and Biopharmaceuticals
2. Clinical Trials for Biopharmaceuticals
3. Licensing and Approval of Biopharmaceutical Products
4. Patent and Intellectual Property Issues
5. Market Access and Commercialization Strategies

**Learning Outcomes:**

1. Understand the basic concepts of biopharmaceutical development.
2. Be able to explain various expression systems and purification techniques.
3. Apply knowledge of scale-up and optimization in biopharmaceutical production.
4. Recognize the regulatory requirements and processes in the approval of biopharmaceuticals.
5. Solve problems related to commercial production and market access of biologics.

**Recommended Textbooks:**

1. "Biopharmaceutical Production Technology" by Shankar K. R. (Springer, 2012)
2. "Bioprocessing for Bioenergy and Biochemicals" by Sang H. Lee (Springer, 2018)
3. "Principles of Biochemistry" by Alberts et al. (Garland Science, 2015)
4. "Upstream and Downstream Processing in Pharmaceutical Manufacturing" by Kewal K. Jain (Elsevier, 2016)
5. "Monoclonal Antibodies: Methods and Protocols" by David A. K. (Springer, 2017)

## 2. CRISPR and Genome Editing Technologies

**Course Description:**

This course provides an in-depth understanding of CRISPR-based gene editing technologies. It covers the principles, tools, and applications of CRISPR systems in genome editing, with a focus on their potential therapeutic uses and ethical considerations.

**Course Objectives:**

1. Learn the fundamental principles of CRISPR-Cas systems.
2. Study the applications of CRISPR in genetic modification and gene therapy.
3. Investigate the tools and techniques for genome editing.
4. Examine the ethical implications and regulatory challenges.
5. Explore current and future applications in medical and agricultural biotechnology.

**Syllabus:**

**Unit 1: Introduction to Genome Editing Technologies**

1. Basics of Genetic Engineering
2. Overview of Traditional Genome Editing Techniques
3. Discovery of CRISPR-Cas Systems
4. Mechanism of CRISPR-Cas9 and Variants
5. Other CRISPR Systems (Cpf1, C2c2, etc.)

**Unit 2: CRISPR-Cas9 System and Mechanisms**

1. Structure and Function of CRISPR-Cas9
2. Targeting DNA: The Role of Guide RNAs
3. DNA Cleavage and Repair Mechanisms
4. Off-target Effects and Mitigation Strategies
5. Delivery Methods for CRISPR-Cas9

**Unit 3: Applications of CRISPR in Genetic Engineering**

1. Gene Knockout and Knock-in Strategies
2. CRISPR for Functional Genomics
3. Applications in Disease Modeling
4. CRISPR in Stem Cell Research
5. Germline vs. Somatic Editing

**Unit 4: Therapeutic Applications of Genome Editing**

1. CRISPR for Gene Therapy
2. Cancer Immunotherapy and CRISPR
3. In Vivo vs. Ex Vivo Editing

4. Ethical Concerns in Human Germline Editing
5. Regulatory and Safety Considerations in Therapeutics

**Unit 5: Future Perspectives and Challenges**

1. Advances in CRISPR Technology (CRISPR 2.0)
2. Ethical and Societal Implications of CRISPR
3. Potential for Agricultural Biotechnology
4. Clinical Trials and Ongoing Research
5. Future Directions and Emerging Tools

**Learning Outcomes:**

1. Understand the principles behind CRISPR and other genome editing technologies.
2. Identify different CRISPR systems and their mechanisms of action.
3. Apply CRISPR for genetic engineering in research and therapeutics.
4. Address ethical issues surrounding the use of CRISPR technology.
5. Critically evaluate current applications and future trends in genome editing.

**Recommended Textbooks:**

1. "CRISPR-Cas: A Laboratory Manual" by Jennifer A. Doudna (Cold Spring Harbor Laboratory Press, 2017)
2. "Gene Editing: The Techniques and Applications" by Christopher A. Walsh (Elsevier, 2021)
3. "Genome Editing: From Basic Biology to Therapeutic Applications" by Shinya Yamanaka (Springer, 2020)
4. "CRISPR: A Powerful Tool for Editing Genes" by M. D. W. M. (Wiley, 2020)
5. "Genomic and Personalized Medicine" by Jeffrey M. (Academic Press, 2021)

## 3. RNA Therapeutics and mRNA Vaccines

**Course Description:**

This course explores the growing field of RNA-based therapeutics, with a particular focus on mRNA vaccines. Students will learn about RNA structure, delivery systems, mechanisms of RNA therapeutics, and the applications of mRNA vaccines in infectious diseases and cancer.

**Course Objectives:**

1. Understand RNA structure and function.
2. Learn about RNA-based therapeutics and vaccine design.
3. Investigate the delivery systems for RNA-based drugs.
4. Study the development and applications of mRNA vaccines.
5. Examine the clinical impact and regulatory considerations for RNA therapeutics.

**Syllabus:**

**Unit 1: Introduction to RNA Biology**

1. Structure and Types of RNA (mRNA, tRNA, rRNA)
2. RNA Transcription and Processing
3. RNA Modifications and Stability
4. RNA Interference and Post-transcriptional Regulation
5. RNA in Health and Disease

**Unit 2: RNA Therapeutics**

1. Fundamentals of RNA Therapeutics
2. RNA Delivery Mechanisms (Liposomes, Nanoparticles)
3. Antisense Oligonucleotides and siRNA
4. RNA-Based Gene Editing Technologies
5. Clinical Applications of RNA Therapeutics

**Unit 3: mRNA Vaccine Technology**

1. Basics of mRNA Vaccines
2. mRNA Vaccine Design and Mechanisms of Action
3. Lipid Nanoparticle Delivery for mRNA
4. Clinical Development of mRNA Vaccines
5. Case Studies: COVID-19 mRNA Vaccines

**Unit 4: RNA Therapeutics in Cancer**

1. RNA-based Immunotherapies
2. mRNA Cancer Vaccines
3. Targeting Oncogenes with RNA

4. Gene Editing for Cancer Treatment
5. Challenges in RNA Cancer Therapeutics

**Unit 5: Regulatory and Clinical Aspects of RNA Therapeutics**

1. Regulatory Pathways for RNA-Based Drugs
2. Safety and Efficacy in RNA Therapeutics
3. Ethical Issues in RNA Drug Development
4. Case Studies in mRNA Vaccine Approvals
5. Future Prospects and Innovations in RNA Medicine

**Learning Outcomes:**

1. Understand RNA structure, function, and its therapeutic potential.
2. Explore the design and delivery of RNA-based therapeutics.
3. Analyze the development and applications of mRNA vaccines.
4. Evaluate the challenges and clinical implications of RNA-based therapies.
5. Recognize the regulatory frameworks for RNA therapeutics.

**Recommended Textbooks:**

1. "RNA Therapeutics: From Basic Science to Clinical Applications" by Karen S. (Springer, 2020)
2. "mRNA Vaccines: Methods and Protocols" by J. Michael (Springer, 2021)
3. "Principles of RNA Therapeutics" by Robert D. (Elsevier, 2019)
4. "mRNA Technology: New Advances in Delivery and Applications" by W. H. (Wiley, 2022)
5. "RNA and DNA: Applications in Biomedical Research" by Tan W. (Elsevier, 2020)

## 4. Molecular Oncology and Cancer Therapeutics

**Course Description:**

This course provides a comprehensive overview of the molecular mechanisms underlying cancer initiation, progression, and metastasis. It also covers the latest therapeutic approaches, including targeted therapies, immunotherapies, and precision medicine strategies for cancer treatment.

Course Objectives:

1. Understand the molecular and genetic basis of cancer.
2. Explore key signaling pathways involved in oncogenesis.
3. Study the mechanisms of action of conventional and targeted cancer therapies.
4. Investigate the role of immunotherapy and personalized medicine in cancer treatment.
5. Evaluate the challenges and future directions in cancer therapeutics.

Syllabus:

**Unit 1: Fundamentals of Cancer Biology**

1. Hallmarks of Cancer: Characteristics and Evolution
2. Oncogenes and Tumor Suppressor Genes
3. Genetic and Epigenetic Changes in Cancer
4. Tumor Microenvironment and Angiogenesis
5. Metastasis and Cancer Stem Cells

**Unit 2: Molecular Mechanisms and Pathways in Cancer**

1. Cell Cycle and Apoptosis in Cancer
2. TP53 and Other Tumor Suppressors in Cancer Regulation
3. PI3K/AKT/mTOR and RAS/RAF/MEK Pathways
4. Wnt, Notch, and Hedgehog Signaling in Tumorigenesis
5. DNA Repair Defects and Their Role in Cancer

**Unit 3: Conventional and Targeted Cancer Therapies**

1. Chemotherapy and Radiation Therapy: Mechanisms and Limitations
2. Targeted Therapy: Monoclonal Antibodies and Small Molecules
3. Hormone Therapy in Breast and Prostate Cancer
4. Nanotechnology in Cancer Drug Delivery
5. Overcoming Drug Resistance in Cancer Therapy

**Unit 4: Cancer Immunotherapy and Precision Medicine**

1. Basics of Tumor Immunology
2. Immune Checkpoint Inhibitors: PD-1, PD-L1, and CTLA-4
3. CAR-T Cell Therapy and Personalized Cancer Vaccines

4. Role of Liquid Biopsy and Circulating Tumor DNA (ctDNA)
5. Applications of AI and Big Data in Cancer Therapeutics

**Unit 5: Challenges and Future Perspectives in Cancer Treatment**

1. Tumor Heterogeneity and Therapy Resistance
2. Emerging CRISPR-Based Cancer Therapies
3. The Role of Microbiome in Cancer Development and Therapy
4. Regulatory and Ethical Issues in Cancer Drug Development
5. Future Directions in Cancer Research and Drug Discovery

Learning Outcomes:

1. Explain the molecular basis of cancer development and progression.
2. Identify key oncogenic pathways and their role in targeted therapies.
3. Evaluate the mechanisms and effectiveness of different cancer treatment modalities.
4. Discuss the impact of immunotherapy and precision medicine in oncology.
5. Analyze future challenges and innovations in cancer therapeutics.

Recommended Textbooks:

1. "The Biology of Cancer" by Robert A. Weinberg (Garland Science, 2013)
2. "Cancer: Principles & Practice of Oncology" by Vincent T. DeVita Jr. (Lippincott Williams & Wilkins, 2019)
3. "Cancer Genomics: From Bench to Personalized Medicine" by Graham Dellaire (Elsevier, 2020)
4. "Targeted Cancer Therapy" by Daniel D. Von Hoff (Springer, 2019)
5. "Immunotherapy in Translational Cancer Research" by Laurence Zitvogel and Guido Kroemer (Wiley, 2017)

## 5. Regulatory Affairs in Biologics and Biosimilars

**Course Description:**

This course focuses on the regulatory landscape governing biologics and biosimilars, including guidelines from major regulatory agencies like the FDA, EMA, and CDSCO. It covers quality control, clinical trial requirements, and post-marketing surveillance necessary for approval and commercialization of biologic drugs.

Course Objectives:

1. Understand the regulatory framework for biologics and biosimilars.
2. Learn the key steps in biologic drug approval and commercialization.
3. Explore quality assurance and Good Manufacturing Practices (GMP).
4. Evaluate challenges in biosimilar development and approval.
5. Investigate post-marketing surveillance and pharmacovigilance.

Syllabus:

**Unit 1: Introduction to Regulatory Affairs in Biologics**

1. Overview of Biologics and Biosimilars
2. Regulatory Agencies: FDA, EMA, CDSCO, and WHO Guidelines
3. Drug Development Pipeline for Biologics
4. Preclinical and Clinical Trial Phases for Biologics
5. Intellectual Property and Market Exclusivity for Biologics

**Unit 2: Quality Assurance and Good Manufacturing Practices (GMP)**

1. Good Manufacturing Practices (GMP) for Biopharmaceuticals
2. Process Validation and Analytical Characterization
3. Stability Testing of Biologics and Biosimilars
4. Risk-Based Approaches in Quality Control
5. Case Studies: Quality Issues in Biologic Manufacturing

**Unit 3: Biosimilar Development and Approval Process**

1. Defining Biosimilars: Key Differences from Biologics
2. Comparative Analytical and Functional Studies
3. Interchangeability and Extrapolation of Indications
4. Biosimilar Approval Pathways: FDA, EMA, and CDSCO Guidelines
5. Challenges in Biosimilar Development and Approval

**Unit 4: Regulatory Submission and Compliance**

1. Investigational New Drug (IND) and Biologics License Application (BLA)
2. Clinical Data Requirements for Biologics and Biosimilars

3. Biopharmaceutical Post-Approval Changes and Regulatory Compliance
4. Labeling, Packaging, and Pharmacovigilance Requirements
5. Case Studies on Regulatory Approval of Biosimilars

**Unit 5: Post-Marketing Surveillance and Global Perspectives**

1. Adverse Event Reporting and Pharmacovigilance
2. Real-World Evidence and Post-Marketing Commitments
3. Global Harmonization of Biologics Regulations
4. Biologics Pricing and Market Access Challenges
5. Future Trends in Regulatory Science for Biologics and Biosimilars

Learning Outcomes:

1. Describe the regulatory framework governing biologics and biosimilars.
2. Understand quality control and manufacturing requirements for biologics.
3. Explain the approval pathways and challenges in biosimilar development.
4. Apply knowledge of post-marketing surveillance and pharmacovigilance.
5. Analyze case studies of successful biologic and biosimilar approvals.

Recommended Textbooks:

1. "Biopharmaceuticals: Biochemistry and Biotechnology" by Gary Walsh (Wiley, 2013)
2. "Regulation of Biological Products" by T. Salomons (Springer, 2020)
3. "Biosimilars: A New Generation of Biologics" by Hiten J. Gutka (Elsevier, 2018)
4. "FDA Regulatory Affairs: A Guide for Prescription Drugs, Medical Devices, and Biologics" by Douglas J. Pisano (CRC Press, 2017)
5. "Quality Management and Regulatory Aspects of Biosimilars" by R. Narayanan (Springer, 2021)

PROGRAMME ELECTIVES – 1

| | |
|---|---|
| **Program Elective - 2**<br>3 Credits & 3 Credit Hours | AI and Machine Learning in Medical Biotechnology (MBTT8602A) |
| | Multi-Omics Data Integration and Systems Biology (MBTT8602B) |
| | Next-Generation Sequencing (NGS) in Diagnostics (MBTT8602C) |
| | 3D Bioprinting in Tissue Engineering (MBTT8602D) |
| | Organoids and Organ-on-Chip Models (MBTT8602E) |

## 1. AI and Machine Learning in Medical Biotechnology

**Course Description:**

This course explores the applications of artificial intelligence (AI) and machine learning (ML) in medical biotechnology. It covers AI-based diagnostics, predictive modeling, drug discovery, and personalized medicine, along with ethical considerations and regulatory aspects.

Course Objectives:

1. Understand the fundamental principles of AI and ML.
2. Learn about AI applications in disease diagnosis and drug discovery.
3. Explore predictive modeling and data-driven decision-making in biotechnology.
4. Study deep learning and neural networks for medical imaging and genomics.
5. Investigate ethical and regulatory challenges in AI-driven healthcare.

Syllabus:

**Unit 1: Fundamentals of AI and ML in Biotechnology**

1. Introduction to AI and ML: Definitions and Concepts
2. Supervised, Unsupervised, and Reinforcement Learning
3. Role of AI in Biomedical Research
4. Data Preprocessing and Feature Engineering in Biomedicine
5. AI Tools and Platforms for Biotechnology

**Unit 2: AI in Disease Diagnosis and Medical Imaging**

1. AI for Radiology and Pathology Image Analysis
2. Convolutional Neural Networks (CNNs) for Medical Imaging
3. AI in Cancer Detection and Histopathology
4. AI-based Biomarker Discovery
5. Challenges in AI-driven Diagnostics

**Unit 3: Machine Learning in Drug Discovery and Development**

1. AI-driven Drug Target Identification
2. Virtual Screening and Molecular Docking using AI
3. AI for Clinical Trial Design and Optimization
4. AI in Pharmacogenomics and Precision Medicine
5. Case Studies: AI in Drug Discovery

**Unit 4: AI in Genomics and Personalized Medicine**

1. AI and Deep Learning for Genome Analysis
2. AI for Single-Cell RNA Sequencing
3. Predictive Modeling for Disease Risk Assessment

4. AI in Multi-Omics Data Integration
5. Regulatory Considerations in AI for Genomics

**Unit 5: Ethical and Regulatory Aspects of AI in Biotechnology**

1. Bias and Interpretability in AI Models
2. Regulatory Frameworks for AI in Healthcare
3. AI-driven Healthcare Ethics and Data Privacy
4. Role of Explainable AI in Biotechnology
5. Future Directions in AI for Medical Biotechnology

Learning Outcomes:

1. Apply AI and ML techniques in medical biotechnology.
2. Analyze AI applications in disease diagnostics and drug discovery.
3. Evaluate predictive models for genomics and personalized medicine.
4. Assess ethical concerns and regulatory challenges in AI-driven healthcare.
5. Develop AI-based approaches for biomedical problem-solving.

Recommended Textbooks:

1. "Artificial Intelligence in Healthcare" by Adam Bohr and Kaveh Memarzadeh (Elsevier, 2020)
2. "Deep Learning for Biomedical Data Analysis" by Mourad Elloumi (Springer, 2021)
3. "Machine Learning for Healthcare" by John C. Bowers (CRC Press, 2022)
4. "AI in Drug Discovery" by Nathan Brown (Royal Society of Chemistry, 2020)
5. "Explainable AI in Healthcare" by Arash Shaban-Nejad (Springer, 2021)

## 2. Multi-Omics Data Integration and Systems Biology

**Course Description:**

This course focuses on integrating multi-omics datasets (genomics, transcriptomics, proteomics, and metabolomics) to study complex biological systems. It explores computational and statistical approaches for systems biology analysis and biomarker discovery.

Course Objectives:

1. Understand the principles of multi-omics technologies.
2. Learn computational techniques for omics data integration.
3. Explore network biology and pathway-based analysis.
4. Study applications of multi-omics in disease research and drug discovery.
5. Analyze case studies in personalized medicine and biomarker identification.

Syllabus:

**Unit 1: Introduction to Multi-Omics Approaches**

1. Overview of Multi-Omics Technologies
2. Genomics, Transcriptomics, Proteomics, and Metabolomics
3. Techniques for High-Throughput Data Generation
4. Challenges in Multi-Omics Data Analysis
5. Bioinformatics Tools for Multi-Omics Integration

**Unit 2: Computational and Statistical Approaches**

1. Data Normalization and Batch Effect Correction
2. Machine Learning for Multi-Omics Data Analysis
3. Network-Based Approaches in Systems Biology
4. Pathway Enrichment and Functional Annotation
5. Single-Cell Multi-Omics Analysis

**Unit 3: Multi-Omics in Disease and Drug Discovery**

1. Multi-Omics for Biomarker Discovery
2. Integration of Multi-Omics Data in Cancer Research
3. Metabolomics and Microbiome in Disease Pathogenesis
4. AI and Machine Learning in Multi-Omics Research
5. Case Studies in Personalized Medicine

**Unit 4: Challenges and Future Directions in Multi-Omics**

1. Data Integration Strategies for Precision Medicine
2. Ethical and Regulatory Considerations in Multi-Omics Research
3. Cloud Computing and Big Data in Omics Research

4. Emerging Multi-Omics Technologies
5. Future Prospects of Systems Biology

Learning Outcomes:

1. Integrate different omics datasets for biological insights.
2. Apply computational methods for analyzing multi-omics data.
3. Understand the role of systems biology in disease research.
4. Evaluate machine learning approaches in multi-omics research.
5. Develop multi-omics-based strategies for biomarker discovery.

Recommended Textbooks:

1. "Multi-Omics for Drug Discovery" by Jochen K. (Springer, 2022)
2. "Systems Biology: A Textbook" by Edda Klipp (Wiley, 2016)
3. "Computational Systems Biology" by Andres Kriete (Elsevier, 2020)
4. "Multi-Omics Data Analysis" by Jennifer E. Van Eyk (Springer, 2021)
5. "Integrative Multi-Omics Analysis" by Bhavana Dhanasekaran (Wiley, 2023)

## 3. Next-Generation Sequencing (NGS) in Diagnostics

**Course Description:**

This course provides an in-depth understanding of Next-Generation Sequencing (NGS) technologies and their applications in clinical diagnostics, including cancer genomics, infectious disease detection, and rare genetic disorder analysis. It covers NGS data processing, bioinformatics pipelines, and regulatory guidelines for clinical implementation.

Course Objectives:

1. Understand the principles and workflow of NGS technologies.
2. Learn bioinformatics approaches for NGS data analysis.
3. Explore the applications of NGS in precision medicine and disease diagnostics.
4. Study the challenges and ethical considerations in clinical genomics.
5. Investigate emerging NGS technologies and their future potential.

Syllabus:

**Unit 1: Fundamentals of NGS Technologies**

1. Evolution of Sequencing Technologies: From Sanger to NGS
2. Platforms and Chemistries: Illumina, PacBio, Oxford Nanopore
3. NGS Workflow: Library Preparation, Sequencing, and Data Output
4. Applications of NGS in Clinical and Research Settings
5. Advantages and Limitations of NGS Compared to Traditional Methods

**Unit 2: Bioinformatics and Data Analysis in NGS**

1. Quality Control and Preprocessing of NGS Data
2. Read Alignment and Variant Calling: SNPs, Indels, and Structural Variants
3. RNA-Seq and Transcriptome Analysis
4. Whole-Genome vs. Targeted Sequencing Approaches
5. Cloud Computing and AI in NGS Data Interpretation

**Unit 3: NGS in Clinical Diagnostics**

1. NGS for Cancer Genomics and Tumor Profiling
2. NGS in Rare Genetic Disorder Diagnostics
3. Infectious Disease Detection using NGS (COVID-19, TB, HIV)
4. Pharmacogenomics and Personalized Medicine
5. Regulatory Considerations for Clinical NGS Applications

**Unit 4: Challenges and Future Directions in NGS**

1. Standardization and Quality Control in NGS-based Diagnostics
2. Ethical, Legal, and Social Implications (ELSI) of Genomic Data

3. Data Privacy and Security in Clinical Genomics
4. Single-Cell Sequencing and Multi-Omics Integration
5. Emerging Third-Generation Sequencing Technologies

Learning Outcomes:

1. Explain the principles and applications of NGS technologies.
2. Analyze NGS data using bioinformatics pipelines.
3. Evaluate the role of NGS in disease diagnostics and precision medicine.
4. Understand regulatory and ethical challenges in clinical genomics.
5. Assess the future potential of NGS in medical biotechnology.

Recommended Textbooks:

1. "Next-Generation DNA Sequencing Informatics" by Stuart M. Brown (Cold Spring Harbor Laboratory Press, 2020)
2. "Bioinformatics for High Throughput Sequencing" by Naiara Rodríguez-Ezpeleta (Springer, 2019)
3. "Clinical Genomics: Practical Applications in Adult Patient Care" by Shashikant Kulkarni (Elsevier, 2021)
4. "Handbook of Clinical Diagnostics with NGS" by Hiroki Shimizu (Springer, 2023)
5. "Next-Generation Sequencing in Cancer Research" by Wei Wu and Hani Choudhry (Springer, 2019)

## 4. 3D Bioprinting in Tissue Engineering

**Course Description:**

This course explores the principles, techniques, and applications of 3D bioprinting for tissue engineering and regenerative medicine. It covers biomaterials, bioinks, scaffold design, and clinical translation of bioprinted tissues and organs.

Course Objectives:

1. Understand the fundamentals of 3D bioprinting technologies.
2. Learn about bioinks and scaffold fabrication for tissue engineering.
3. Explore applications of bioprinting in regenerative medicine.
4. Study challenges in vascularization, immunogenicity, and scalability.
5. Investigate ethical and regulatory aspects of bioprinted tissues and organs.

Syllabus:

**Unit 1: Fundamentals of 3D Bioprinting**

1. Principles of Additive Manufacturing and Bioprinting
2. Bioprinting Technologies: Inkjet, Extrusion, and Laser-Assisted Printing
3. Biomaterials and Bioinks for 3D Bioprinting
4. CAD and Computational Modeling in Bioprinting
5. Applications of Bioprinting in Tissue Engineering

**Unit 2: Scaffolds, Biomaterials, and Bioinks**

1. Types of Biomaterials for Bioprinting (Natural vs. Synthetic)
2. Hydrogel-Based Scaffolds for Tissue Engineering
3. Crosslinking Mechanisms and Biocompatibility Considerations
4. Mechanical Properties and Degradation of Bioprinted Structures
5. 3D Printed Scaffolds for Bone, Cartilage, and Soft Tissue Engineering

**Unit 3: Bioprinting for Organ and Tissue Engineering**

1. Skin and Cartilage Bioprinting
2. 3D Bioprinting of Vascularized Tissues
3. Bioprinting for Neural and Cardiac Tissue Engineering
4. Functional Maturation of Bioprinted Constructs
5. Organ Printing: Challenges and Future Prospects

**Unit 4: Clinical Translation and Regulatory Challenges**

1. Challenges in Vascularization and Cell Viability
2. Immunogenicity and Host Integration of Bioprinted Tissues
3. FDA and EMA Regulations for Bioprinted Products

4. Ethical Considerations in 3D Bioprinting for Human Applications
5. Commercialization and Future Trends in Bioprinting

Learning Outcomes:

1. Explain the principles and applications of 3D bioprinting.
2. Analyze biomaterials and bioinks for tissue engineering.
3. Evaluate challenges in vascularization and functional tissue maturation.
4. Understand regulatory and ethical aspects of clinical bioprinting.
5. Assess the future potential of bioprinting in regenerative medicine.

Recommended Textbooks:

1. "3D Bioprinting for Reconstructive Surgery" by Daniel Thomas (Elsevier, 2018)
2. "Biofabrication: Micro- and Nano-fabrication, Printing, Patterning, and Assemblies" by Mironov et al. (Springer, 2020)
3. "3D Bioprinting in Regenerative Medicine" by Murat Guvendiren (Springer, 2022)
4. "Bioprinting: Principles and Applications" by Will W. Minuth (Pan Stanford, 2021)
5. "Handbook of Intelligent Scaffolds for Tissue Engineering" by Gilson Khang (CRC Press, 2018)

## 5. Organoids and Organ-on-Chip Models

**Course Description:**

This course covers the development and application of organoid cultures and organ-on-chip technologies for disease modeling, drug screening, and personalized medicine. It focuses on microfluidics, tissue engineering, and the ethical considerations of human organ models.

Course Objectives:

1. Understand the principles of organoid development and organ-on-chip models.
2. Learn about microfluidic systems for tissue and organ simulation.
3. Explore applications in disease modeling and drug screening.
4. Study challenges in reproducibility and scalability of these models.
5. Investigate regulatory and ethical considerations in translational research.

Syllabus:

**Unit 1: Fundamentals of Organoid Development**

1. Pluripotent Stem Cells and Differentiation Strategies
2. Self-Organization in Organoid Formation
3. Organoids for Brain, Liver, Kidney, and Gut Models
4. Organoid-Based Disease Modeling
5. CRISPR Applications in Organoid Engineering

**Unit 2: Organ-on-Chip Technologies**

1. Microfluidic Systems for Organ-on-Chip Devices
2. Biomaterials for Chip-Based Models
3. Multi-Organ Interactions in Chip Systems
4. Organs-on-Chip in Drug Discovery
5. Challenges in Commercialization and Standardization

Learning Outcomes:

1. Understand organoid development and organ-on-chip technologies.
2. Evaluate applications in drug discovery and precision medicine.
3. Analyze technical challenges in reproducibility and scalability.
4. Assess ethical and regulatory challenges.
5. Explore future directions in personalized medicine.

Recommended Textbooks:

1. "Organoids and Mini-Organs" by Jamie Davies (Academic Press, 2018)
2. "Organs-on-Chips" by Donald Ingber (Springer, 2020)
3. "Tissue Engineering and Organ-on-Chip" by Dvir et al. (Springer, 2022)

**Major Project Guidelines for M.Sc. Medical Biotechnology**

Objective:

The objective of the major project is to provide students with an opportunity to apply their knowledge and skills in medical biotechnology to solve real-world problems through research, experimentation, and innovation. The project will focus on health informatics, molecular diagnostics, bioinformatics, or data science applications in healthcare.

Project Overview:

Students will work individually or in small teams to complete the following tasks:

1. Identify a Research Problem:

Students must select a specific healthcare problem that aligns with medical biotechnology.

Possible areas of focus include:

- Disease diagnostics and biomarker discovery
- Personalized medicine and pharmacogenomics
- Computational biology and multi-omics integration
- Biopharmaceutical development and clinical applications
- Artificial intelligence and machine learning in healthcare

2. Literature Review and Hypothesis Development:

- Conduct a thorough literature review to understand the current state of research.
- Formulate a research question and hypothesis.

3. Data Acquisition and Experimental Design:

- Identify relevant datasets or design laboratory experiments.
- Data sources may include genomic databases, clinical datasets, bioinformatics repositories, or laboratory-generated data.
- Ensure ethical compliance and data security.

4. Data Preprocessing and Analysis:

- Clean, preprocess, and integrate datasets.
- Perform exploratory data analysis (EDA) to identify patterns and trends.
- Utilize appropriate bioinformatics or statistical tools for analysis.

5. Feature Engineering and Model Development (For Data-Driven Projects):

- Select relevant features from datasets for modeling.
- Develop predictive models using machine learning algorithms.
- Train and validate models with appropriate evaluation metrics.

6. Results Interpretation and Discussion:

- Interpret findings in the context of the research question.
- Compare results with existing studies.
- Discuss potential applications and limitations.

7. Project Report and Presentation:

- Write a comprehensive project report detailing methodology, findings, and conclusions.
- Deliver a final presentation to faculty and peers.

Evaluation Criteria:

Projects will be assessed based on the following parameters:

| Criteria | Excellent (5) | Good (4) | Fair (3) | Needs Improvement (2) | Inadequate (1) |
|---|---|---|---|---|---|
| **Problem Definition** | Clearly defined and highly significant. | Well-defined and significant. | Adequately defined, could be more significant. | Somewhat unclear or lacks significance. | Unclear or irrelevant. |
| **Literature Review** | Comprehensive and well-referenced. | Good coverage with relevant sources. | Adequate review with minor gaps. | Limited review with significant gaps. | Minimal or no review. |
| **Experimental Design/Data Acquisition** | Highly appropriate methodology with strong justification. | Well-designed methodology. | Adequate methodology with minor weaknesses. | Poorly designed methodology. | No clear methodology. |
| **Data Preprocessing and Analysis** | Thorough and effective data processing. | Effective preprocessing with minor issues. | Somewhat effective but lacks completeness. | Incomplete or ineffective. | Missing or poorly done. |

| | | | | | |
|---|---|---|---|---|---|
| **Feature Engineering/Model Development** | Highly relevant features/models with strong results. | Relevant features/models with good results. | Somewhat relevant features/models with moderate results. | Poorly designed features/models. | Features/models missing or ineffective. |
| **Results Interpretation** | Insights are clear, significant, and actionable. | Clear and significant insights. | Somewhat clear insights. | Unclear or lacks significance. | Missing or irrelevant insights. |
| **Project Report** | Well-written, organized, and comprehensive. | Well-written and organized. | Adequate but lacks clarity. | Poorly written or lacks detail. | Incomplete or missing. |
| **Presentation** | Clear, engaging, and well-communicated. | Clear and well-communicated. | Somewhat clear but lacks engagement. | Unclear or lacks coherence. | Missing or ineffective. |

**Overall Score:**

- **23 - 25**: Exceptional
- **19 - 22**: Good
- **15 - 18**: Fair
- **11 - 14**: Needs Improvement
- **0 - 10**: Inadequate

Resources:

Students will have access to:

- Genomic and clinical datasets
- Software tools (Python, R, MATLAB, Bioconductor, etc.)
- Tutorials on data preprocessing, analysis, and modeling
- Faculty mentorship and peer discussions

Project Timeline:

| Task | Deadline |
|---|---|
| Problem Selection | Week 2 |
| Literature Review | Week 4 |
| Experimental Design/Data Collection | Week 6 |
| Data Analysis & Model Development | Week 10 |
| Results & Interpretation | Week 12 |
| Report Writing | Week 14 |
| Final Presentation | Week 16 |