CVJ Centre For
Synthetic Biology
& Bio-Manufacturing

COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY

# M.Tech. in Synthetic Biology & Biomanufacturing

## Curriculum

Launchpad to the Next Bio Revolution

2025

# M. Tech. in Synthetic Biology & Biomanufacturing

Industrial synthetic biology and biomanufacturing is poised for substantial expansion as industries worldwide shift towards more designing microbial factories, leading to sustainable and bio-based production methods.

**Market predictions**

The synthetic biology market is experiencing unprecedented growth, projected to expand from USD 19.3 billion in 2024 to USD 61.6 billion by 2029, reflecting a robust CAGR of 26.1%. This surge is driven by advancements in healthcare, industrial biotechnology, and sustainable manufacturing.

Valued at approximately USD 75.0 billion in 2023, the fermentation chemicals market is projected to grow at a CAGR of 6.9% from 2024 to 2030, reaching around USD 120.89 billion by 2030. The precision fermentation market is likely to increase from USD 2.48 billion (2023) to USD 17.43 billion (2028), at a CAGR of 48.1%. The global market for fermented ingredients is expected to grow from USD 47.7 billion (2024) to USD 79.3 billion (2030), CAGR of 8.8%. Anticipated to reach USD 192.17 billion by 2034, up from USD 108.82 billion in 2024, the fermentation products market is expected to exhibit a CAGR of 5.85% over the forecast period.

The M.Tech. program in Synthetic Biology & Biomanufacturing is designed to position young, talented minds at the forefront of this dynamic field, equipping them with the skills and knowledge to perform in the high-demand sectors.

**Why Choose This Program?**

To meet the industry requirements of employment and startups, this attractive programme is offered for the first time in India. Key specialities include:

- Mentorship from leading scientists and industry experts
- Industry-aligned curriculum
- Emphasis on hands-on learning
- Learn from leading professionals and researchers from Industry and Academia
- Skill development
- Networking with key people
- Internship opportunities (India / foreign)
- Career Opportunities in High-Growth Sectors

Graduates will be well-positioned for global careers in:

- **Biopharmaceuticals & Healthcare:** Development of advanced therapeutics, vaccines, and precision medicine.
- **Industrial Biotechnology:** Engineering microbes for sustainable chemicals, materials, and fuels.
- **Agri-Biotech & Food Tech:** Advancing alternative proteins, biofortification, and smart agriculture solutions.
- **Environmental Biotech & Sustainability:** Addressing climate change with carbon capture, bio-remediation, and circular bioeconomy solutions.
- **Startups & Innovation:** Spin off your own biotech venture or join dynamic startups at the forefront of global biotech transformation.
- **Regulatory & Biosecurity Sectors:** Contribute to policymaking and ensuring safe deployment of biotechnology solutions.

**Program Highlights:**

This Master's program in synthetic biology and biomanufacturing, the first one in the country, is designed to provide learners with industry-relevant skills and hands-on expertise to excel in a rapidly changing world.

The courses offered in the first semester are “Level 400”, representing advanced undergraduate or pre-master’s level content designed to build a foundation for a new specialization. The second semester courses are “Level 500”, indicating postgraduate-level depth and complexity, suitable for advanced knowledge and application. Additionally, bridge courses intended to align students from diverse academic backgrounds is “Level 100”, signifying foundational or introductory material.

Learners will be encouraged to network through internships, workshops, industry visits and Conferences. **Semester One** will focus on building foundations in Molecular Biology, mathematics and computation. **Semester Two** will deep dive into Synthetic Biology and manufacturing. Semesters three and four will be reserved for the project. Bridge courses will be offered to fill knowledge gaps wherever needed.

Key features of the project would be solving real-world and industry-relevant problems. It would also encourage critical thinking, problem-solving, and creativity. The project may be completed individually or in teams and would involve integrating knowledge from multiple disciplines or courses. Learners would be encouraged to write a research paper and build a prototype, software application, business plan, or presentation under the supervision of a faculty advisor or industry mentor.

**Teaching Philosophy**

This first-in-the-class program will build practical skills, train students to think beyond the obvious and encourage social responsibility. Synthetic biology and biomanufacturing sit at the crossroads of biology, engineering, computer science, and business. Our approach would be to break down silos to provide learners with a holistic understanding of these interconnected disciplines. We aim to prepare graduates who can think beyond conventional boundaries to drive innovation. Graduates will not only be skilled practitioners but also practice ethical leadership.

Learners will be engaged in research-led teaching, embedded with case studies and hands-on projects, ensuring that learning outcomes directly translate to professional competencies. Learners will learn by designing, building, and testing biological systems in laboratory settings and bioreactors. Capstone projects, internships will provide practical exposure to tools, methods, and challenges, preparing students for both academic and industrial careers.

Faculty and advisors will work closely with students to tailor their educational experiences, helping them align their learning with their career aspirations, whether in academia, entrepreneurship, or industry. The program embraces a global perspective by incorporating best practices, emerging trends, and global challenges in synthetic biology and biomanufacturing. By engaging with industry leaders and collaborating on real-world problems, learners gain insights into the demands and expectations of a rapidly evolving global biotech landscape. We celebrate diverse perspectives, backgrounds, and approaches to problem-solving. By fostering an inclusive environment, we aim to prepare graduates who can thrive in diverse teams and contribute to globally relevant innovations.

Paper degrees are getting increasingly redundant. Grades do not reflect hands-on skills in many cases. The key is to focus on practical skills that are transferrable. Our aim is to generate good unanswered questions in the class. We are not used to predicting and designing the future. This needs to change. Every innovation comes at some cost to the planet. We need all-inclusive and socially responsible innovations that improve quality of life, causing least damage to the environment and uses renewable natural resources.

**Outcome**

- **Cutting-Edge Research Opportunities:** Engage in research projects that contribute to advancements in synthetic biology and biomanufacturing. Hands on experience in the Cell culture, DNA, RNA and protein analysis, DNA amplification and editing, computational genome design, modelling and simulating biological pathways, protein engineering, machine learning, metabolic engineering tools, high throughput technologies, building gene circuits and microbial factories.

- **State-of-the-Art Facilities:** Access modern laboratories and equipment that support innovative research and learning. Familiarity with handling incubators, shakers, biosafety cabinets, centrifuges, microscopes, fermenters, HPLC and liquid-handling systems.

- **Networking and Industry Connections**: Benefit from partnerships with leading organizations, providing avenues for internships and collaborative projects. Future ready for careers in academia, industry, government bodies and entrepreneurship. Graduates will be well-prepared to pursue advanced studies and excel in roles such as R&D, product development, process engineering, and quality assurance. Electives offer exposure to cutting-edge industry trends leading to new thoughts and directions.

# Scheme of Examination for M.Tech. in Synthetic Biology & Biomanufacturing

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Duration of the course 2 years (4 semesters)

**Eligibility:**
Passed B.Tech./B.E. in Chemical Engineering, Bioprocess Engineering, Bioprocess Technology, Biotechnology, Biochemical Engineering, Bioinformatics, Biomedical Engineering, Genetic Engineering, Industrial Biotechnology, M.Sc. in Chemistry, Polymer Chemistry, Biotechnology, Biochemistry with a minimum GPA of 5.0 or 50% marks.

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Accumulated minimum credits required for successful completion of the programme- **88**

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***Year 1*** *will focus on building a* ***strong foundation*** *in both the theoretical aspects of synthetic biology, biomanufacturing and* ***hands-on lab skills****. It includes practical experience in genetic engineering, fermentation, and metabolic engineering. Learners from diverse academic backgrounds will be brought to the same level of understanding through bridging programs. There will be pre-course preparatory training, remedial classes to ensure an uniform participation*

## Semester 1

**23 credits (Core:17 Credits; Elective: 6 credits)**

| Course Code and Title | Instruction | | Evaluation | | Total |
|---|---|---|---|---|---|
| | C/E | Credits | Continuous assessment | Semester End Examination | |
| **Theory (Core)** | | | | | |
| 25-514-0101 Genome Engineering | C | 3 | 50 | 50 | 100 |
| 25-514-0102 Omics and Systems Biology | C | 3 | 50 | 50 | 100 |
| 25-514-0103 Mathematics and Statistics | C | 3 | 50 | 50 | 100 |
| 25-514-0104 Bioinformatics, Databases and Tools | C | 3 | 50 | 50 | 100 |
| **Theory (Elective)** | | | | | |
| Elective 1 | E | 3 | 50 | 50 | 100 |
| Elective 2 | E | 3 | 50 | 50 | 100 |

| | | | | | |
|---|---|---|---|---|---|
| **Lab (Skill Development)** | | | | | |
| 25-514-0105 Lab 1 - Techniques in Cell Culture | C | 2 | 100 | - | 100 |
| 25-514-0106 Lab 2 - Techniques in Molecular Biology | C | 1 | 100 | - | 100 |
| 25-514-0107 Lab 3 - Techniques in Genetic Engineering | C | 2 | 100 | - | 100 |

## Semester 2

**23 credits (Core:17 Credits; Elective: 6 Credits)**

| Course Code and Title | Instruction | | Evaluation | | Total |
|---|---|---|---|---|---|
| **Theory** | **C/E** | **Credits** | **Continuous assessment** | **Semester End Examination** | |
| **Theory (Core)** | | | | | |
| 25-514-0201 Synthetic Biology | C | 3 | 50 | 50 | 100 |
| 25-514-0202 Biomanufacturing | C | 3 | 50 | 50 | 100 |
| 25-514-0203 Bioreactors and Fermentations | C | 3 | 50 | 50 | 100 |
| 25-514-0204 Downstream Processes and Purification | C | 3 | 50 | 50 | 100 |
| **Theory (Elective)** | | | | | |
| Elective 1 | E | 3 | 50 | 50 | 100 |
| Elective 2 | E | 3 | 50 | 50 | 100 |
| **Lab (Skill Development)** | | | | | |
| 25-514-0205 Lab 1 Computational Pathway modelling | C | 1 | 100 | - | 100 |
| 25-514-0206 Lab 2 Bioprocess Engineering | C | 2 | 100 | - | 100 |
| 25-514-0207 Lab 3. Downstream Processing- | C | 2 | 100 | - | 100 |

***Year 2** will **research** opportunities for students to **apply their knowledge** in real-world settings. Hands on training will be more intense, immersive, collaborative and project based. The idea is to empower learners to a level where they can apply theoretical knowledge, lab experience and innovative mind to solve real world problems, take lead and find their career pathway.*

## Semester 3

**24 credits (Core:22 Credits; Elective: 2 credits)**

| Course Code and Title | Instruction | | Evaluation | | Total |
|---|---|---|---|---|---|
| | C/E | Credits | Continuous assessment | Semester End Examination | |
| **Theory (Core)** | | | | | |
| 25-514-0301 Research Methodology | C | 3 | 50 | 50 | 100 |
| 25-514-0302 Intellectual Property Rights | C | 3 | 50 | 50 | 100 |
| **Theory (Elective)** | | | | | |
| MOOC Course | E | ≥2 | - | 100 | 100 |
| **Research Project (Core)** | | | | | |
| **Research Project** | **C/E** | **Credits** | **Assessment by the Research Guide*** | **Assessment by the Examination Committee** | **Total** |
| 25-514-0303 Research Project | C | 16 | 200 | 200 | 400 |

**Based on periodic assessment of the work of the candidate*

## Semester 4

**18 credits (Core:18 Credits)**

| Course Code and Title | Instruction | | Evaluation | | |
|---|---|---|---|---|---|
| | C/E | Credits | Assessment by the Research Guide* | Assessment by the Examination Committee | Total |
| 25-514-0401 Research Project | C | 14 | 200 | 200 | 400 |
| Presentation | | 2 | | 100 | 100 |
| Comprehensive Viva Voce | | 2 | | 100 | 100 |

**Based on periodic assessment of the work of the candidate*

## List of Elective Courses

| | | |
|---|---|---|
| 1) | 25-514-0108 | Chemical Engineering |
| 2) | 25-514-0109 | Natural Products Chemistry |
| 3) | 25-514-0110 | Cellular agriculture: animal & plant-based meat technologies |
| 4) | 25-514-0111 | Enzymology |
| 5) | 25-514-0112 | Quantum Computing in Biology |
| 6) | 25-514-0208 | Cell Free Systems |
| 7) | 25-514-0209 | Artificial Intelligence in Synthetic Biology and Biomanufacturing |
| 8) | 25-514-0210 | DNA origami |
| 9) | 25-514-0211 | 3D Cell Culture and Bioprinting |
| 10) | 25-514-0212 | Long DNA synthesis |
| 11) | 25-514-0213 | Bio Entrepreneurship |

# Syllabi of M. Tech. Synthetic Biology & Biomanufacturing Programme

## Programme Outcome (PO)

NEP 2025 is a transformative policy that aligns India's education system with global standards and industry needs. With its focus on skill development, flexibility, and digital transformation, the policy ensures that students and professionals are equipped with the knowledge and capabilities needed to thrive in a dynamic and competitive world. As India moves towards a knowledge-driven economy, the bold step towards long-term socio-economic development, ensure that future managers, entrepreneurs, and professionals are ready to lead in the global marketplace. The M.Tech programme in Synthetic Biology and Biomanufacturing has been designed with this objective.

## Programme Specific Outcome (PSO)

PSO 1 - Develop expertise in molecule design, circuit design, and cell design

PSO 2 - Gain practical training in DNA editing, strain engineering, and Media engineering

PSO 3 - Learn cell culture, fermentation and downstream processing with industrial applications

PSO 4 - Develop entrepreneurial skills in launching your own biotech company

PSO 5 - Get future-ready for jobs at the interface of science and commercialization

**Definition**
*"Synthetic Biology is a rational design and construction of functional biological components leading to applications. Biomanufacturing is the process of using living cells, microbes, or biological systems to produce products".*

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