India's Translational Research Initiative

India led collaborative philanthropic initiative to accelerate “Lab-to-Market” transformations

Concept Note

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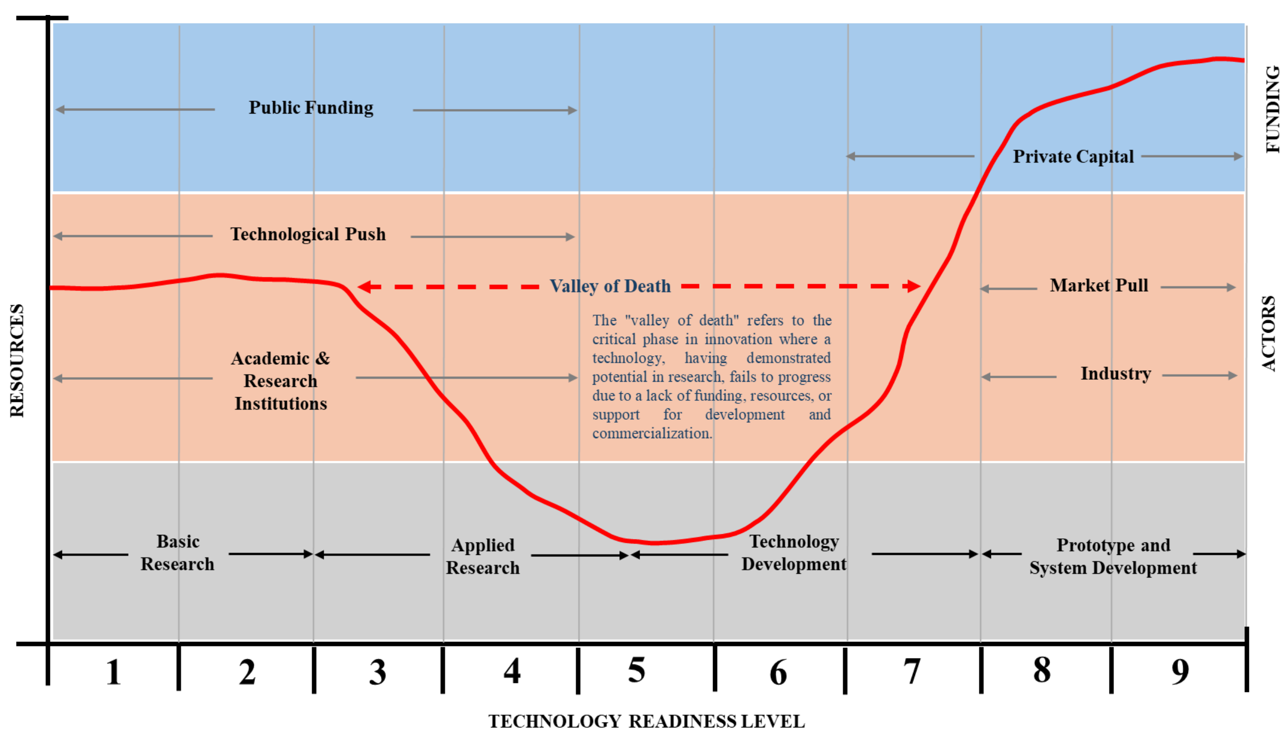
Executive Summary

The India's Translational Research Initiative (ITRI), conceptualized and led by Spectrum Impact, aims to bridge the gap between cutting-edge research and market-ready applications by creating a robust ecosystem for translational research. Aligned with India's national priorities, the initiative addresses critical barriers to innovation, leveraging public-private partnerships to ensure the effective commercialization of technologies. ITRI focuses on building critical infrastructure and fostering innovation to commercialize technologies that address India's national priorities and drive its transformation into a developed nation by 2047.

Key Objectives:

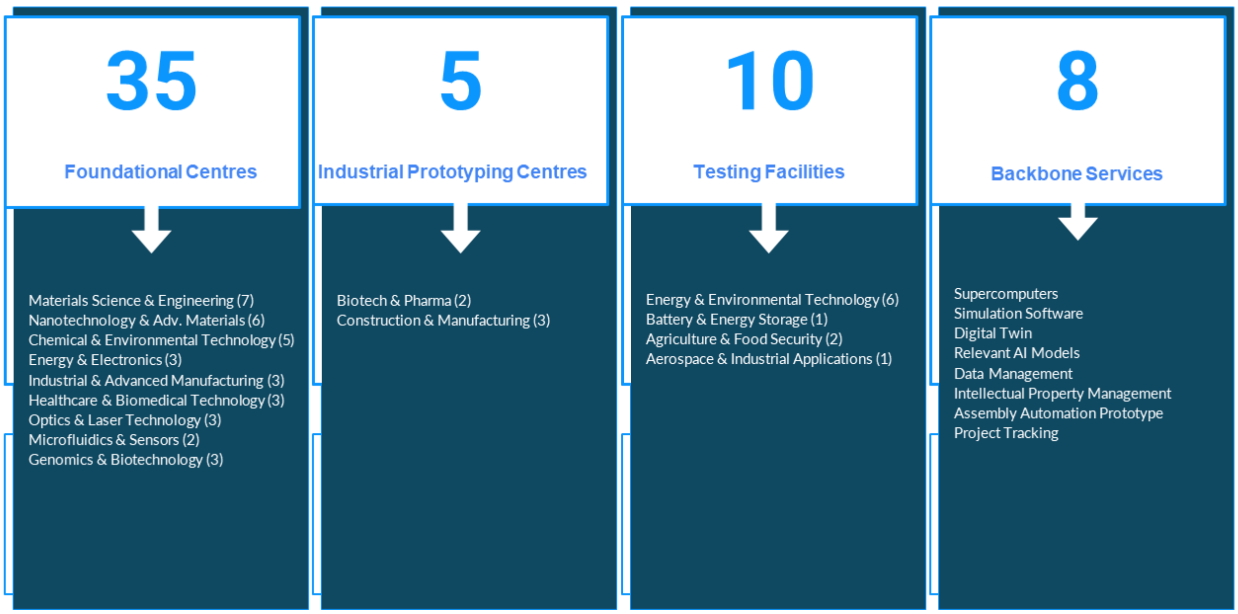
- **Build Critical Infrastructure**:
  - ➢ Establish/augment end-use agnostic translational research centres with advanced facilities for testing, rapid prototyping, and scaling innovations.
  - ➢ Support mid-stage research (TRL 4-7) to bridge the gap between laboratory discoveries and market-ready solutions.
  - ➢ Create a network of backbone services by leveraging advanced computational tools, including simulations, AI models, and digital twins, to streamline and enhance research transitions by creating a shared services model.
- **Enable Entrepreneurship**:
  - ➢ Use shared facilities and services as a launchpad for startups and innovators.
  - ➢ Create opportunities for industrial collaborations that lead to job creation and economic multiplier effect.
- **Foster Capital and Industry Engagement**:
  - ➢ Attract investments by creating reliable pathways for translating research into validated marketable products to build investor confidence.
  - ➢ Strengthen links between research institutions, industries, and venture capital networks.
- **Nation-Building Vision**:
  - ➢ Enable regional economic development by setting up infrastructure hubs across the country.



Technology Readiness Level (TRL) is a nine-point scale that measures a technology's maturity, from basic research to full operational deployment

Key Technology Focus Areas:

- Foundational focus on materials (e.g., membranes, ceramics, 2D materials), advanced manufacturing, and biotech piloting facilities.
- Industrial prototyping for decarbonization, biopharma, and solar energy.
- Testing facilities for renewable energy, agriculture, and ocean technologies.



Proposed Strategy:

- **Overcoming the "Valley of Death"**: Address critical funding and resource challenges at the TRL 4-7 stages.
- **Encouraging Private Capital**: Foster public-private partnerships to catalyze translational research, leveraging philanthropic and corporate investments.
- **Global Collaborations**: Adopt best practices from leading nations like Germany, Israel, and the US to enhance research outcomes.
- **Stakeholder Engagement**: Target universities, innovation hubs, and industry partners to drive a cohesive research-to-commercialization pipeline.

Implementation and Governance:

The initiative outlines a phased approach, including:

- Mapping institutes capable of housing thematic centres.
- Soliciting proposals and assessing institute readiness.
- Aligning with corporates and philanthropists to secure funding and partnerships.
- Instituting a governance framework for transparency, accountability, and efficiency.

Impact:

The ITRI aims to position India as a global leader in research and development by fostering innovation, driving economic growth, and enhancing national security. It is expected to accelerate India's journey toward becoming a developed nation by 2047, aligning with key policy goals and advancing sustainable industrial and societal progress.

India's Translational Research Initiative: Accelerating Lab-to-Market Transformations

Introduction

This document on India's Translational Research Initiative (ITRI) outlines a comprehensive initiative aiming to bolster translational research in India, aligning with national priorities and the vision of making India a developed nation by 2047. Emphasizing the critical role of private capital, the initiative seeks to create a robust framework for advancing translational research across multiple thematic areas. It aims to build a strong infrastructure and foster a culture of translational research by bridging the gap between cutting-edge research and practical, market-ready applications. This transformative endeavor underscores the need to establish foundational capabilities, testing facilities, and collaborative ecosystems to drive innovation and self-reliance in critical sectors, contributing to India's journey toward sustainable development and global leadership.

Supporting the National Agenda

India's focus on innovation, manufacturing excellence, and global competitiveness underscores the need for transformative initiatives that bridge the gap between groundbreaking research and industrial application. This translational research initiative is designed to cultivate a culture of innovation, drive economic growth, and establish India as a global leader in research and development. Strengthening foundational capabilities, industrial prototyping, and advanced testing facilities will play a pivotal role in securing the nation's future, enhancing national resilience, and achieving the goal of becoming a developed country by 2047 while advancing toward net-zero targets by 2070.

Countries like the United States, Germany, and Taiwan have demonstrated the transformative power of strategic investments in translational research. The U.S., a pioneer in this field, established frameworks like the Bayh-Dole Act to ensure the commercialization of federally funded research, bridging the "valley of death." With institutions such as DOE National Labs and programs like NSF I-Corps, the U.S. has driven innovations from laboratory prototypes to market-ready solutions, evidenced by the rapid development of mRNA vaccines. Similarly, Germany's Fraunhofer Society has institutionalized technology transfer, transitioning scientific breakthroughs to industrial success through a well-funded and collaborative ecosystem. Taiwan, through the Industrial Technology Research Institute, has catalyzed its semiconductor industry, turning academic insights into global dominance led by TSMC. These nations have established that targeted investments, robust public-private partnerships, and sector-specific innovation hubs can accelerate technological breakthroughs, scale industries, and create significant economic and societal value.

Nationwide efforts in translational research for India are crucial to foster cross-pollination of ideas across disciplines, leveraging diverse expertise for breakthrough innovations. A unified framework ensures efficient use of capital, reduces duplication, and builds shared infrastructure that lowers costs and enhances scalability. By promoting interdisciplinary collaboration between sectors like engineering, healthcare, and IT, such efforts enable holistic solutions to complex challenges. Moreover, a coordinated approach aligns with India's vision of becoming a global innovation leader and achieving its 2047 development goals.

Objectives

In this context, the objectives of the proposed initiative include:

- **Enhance Foundational Capabilities**: Develop or augment research and development infrastructure supporting diverse scientific inquiries and innovations from technology readiness level (TRL) 4 to TRL 7.
- **Promote Industrial Prototyping**: Facilitate commercial validation of research through collaboration with industry partners.
- **Establish Testing Facilities**: Provide **TRL 4-7** level testing facilities to bridge the gap between research and market-ready products.
- **Expand Computational Facilities**: Support advanced simulations and digitization efforts to accelerate research and development processes toward market transition. Operating as a shared service model, these services will streamline operational efficiencies and reduce duplication of resources.
- **Focus on Commercialization**: Prioritize commercialization alongside intellectual property (IP) generation.

Championing Private Capital

To champion private capital in translational research, we advocate for a synergistic approach that combines private and public funding. Encouraging private capital participation is essential for driving innovation and accelerating research outcomes. By complementing public funding with private investments, we can enhance the impact of public research efforts. Creating Public-Private Partnerships (PPPs) will facilitate shared investment and risk by leveraging domestic philanthropy, Corporate Social Responsibility (CSR), and industry sponsorships.

Accelerating Translational Research: Removing Barriers to Success

Technology Readiness Levels (TRLs) gauge the maturity of a technology from initial concept (TRL 1) to full market deployment (TRL 9). To accelerate translational research, it is crucial to identify key areas where TRL 4-7 piloting facilities are needed and where the deployment of private capital can have a catalytic impact. Selecting the right institutions to house these piloting facilities is essential for fostering innovation. Developing targeted strategies to address existing bottlenecks and leverage private capital to solve critical challenges will streamline the transition from research to market-ready applications, thereby driving significant advancements in translational research.

The "valley of death" refers to the critical phase in innovation where a technology, having demonstrated potential in research, fails to progress due to a lack of funding, resources, or support for development and commercialization. Bridging this gap is vital for India to ensure that promising research translates into market-ready products, driving economic growth, fostering innovation, and maintaining global competitiveness. Addressing the valley of death involves increasing investment in translational research, enhancing industry-academia collaboration, and creating supportive policies to facilitate the journey from lab to market.

Existing Initiatives

The following key initiatives attempt to bridge the gap in the lab-to-market transition of innovations in specific thematic areas from academia and research institutions in India.

1. ***National Centre for Combustion Research and Development (NCCRD), IIT Madras***: The National Centre for Combustion Research and Development (NCCRD) at IIT Madras, supported by the Department of Science and Technology (DST), focuses on advanced research in automotive, thermal power, aerospace propulsion, fire research, and microgravity combustion. The Centre aims to enhance academic research and develop a skilled workforce in combustion sciences. Notably, the start-up "Agnikul Cosmos" was born out of this centre, significantly impacting the aerospace sector by developing affordable and innovative small satellite launch solutions, further exemplifying the Centre's contribution to practical and transformative technological advancements.

2. ***LC^3 Lab, IIT Delhi***: The LC^3 (Limestone Calcined Clay Cement) project at IIT Delhi is dedicated to developing sustainable cement alternatives to reduce CO_2 emissions in the construction industry. This initiative received funding from various international and national organizations, including research grants and private investments. Integrating private and philanthropic capital has accelerated research and development, resulting in practical solutions now being implemented globally, showcasing the potential for significant environmental impact. As a part of its commitment to global scientific outreach, an LC^3-Technology Resource Centre (TRC) Africa Project at Kenya’s Meru University of Science and Technology has been set up under the mentorship of IIT Delhi.

3. ***Centre for Cellular and Molecular Platforms (C-CAMP)***: The Centre for Cellular and Molecular Platforms (C-CAMP) has emerged as a cornerstone in advancing translational research and innovation in life sciences in India. C-CAMP bridges the gap between scientific discovery and market-ready solutions by fostering entrepreneurship and providing state-of-the-art facilities. Its initiatives, such as the Accelerator Program for Startups and the Discovery to Innovation Acceleration Platform, have catalyzed over 300

deep-tech startups and facilitated groundbreaking advancements in biotechnology, agriculture, and healthcare. Success stories include innovations in affordable diagnostics, precision agriculture, and life-saving therapeutics, many of which have scaled to global markets. With over 200 patents supported and partnerships with leading global research organizations, C-CAMP has enabled cutting-edge research to translate into tangible societal and economic impact. Its efforts are creating a robust life sciences innovation ecosystem and positioning India as a global hub for life sciences research and development.

4. ***Wadhwani Research Centre for Bioengineering (WRCB), IIT Bombay***: Wadhwani Research Centre for Bioengineering (WRCB) at IIT Bombay aims to foster interdisciplinary research in bioengineering and healthcare innovation. Funded by the Wadhwani Foundation, this centre leverages private and philanthropic capital to support cutting-edge research, the development of medical technologies, and translating these innovations into market-ready solutions. The impact includes numerous patents, startups, and medical diagnostics and treatment advancements, significantly contributing to healthcare improvements.

5. ***Gogri Hub for Membranes Research, IIT Bombay***: The Gogri Hub for Membranes Research will focus on pioneering translational research in membrane technology with water purification, energy, and healthcare applications. Supported by philanthropic contributions from the Gogri family, this initiative emphasizes the transition from lab-based research to market applications.

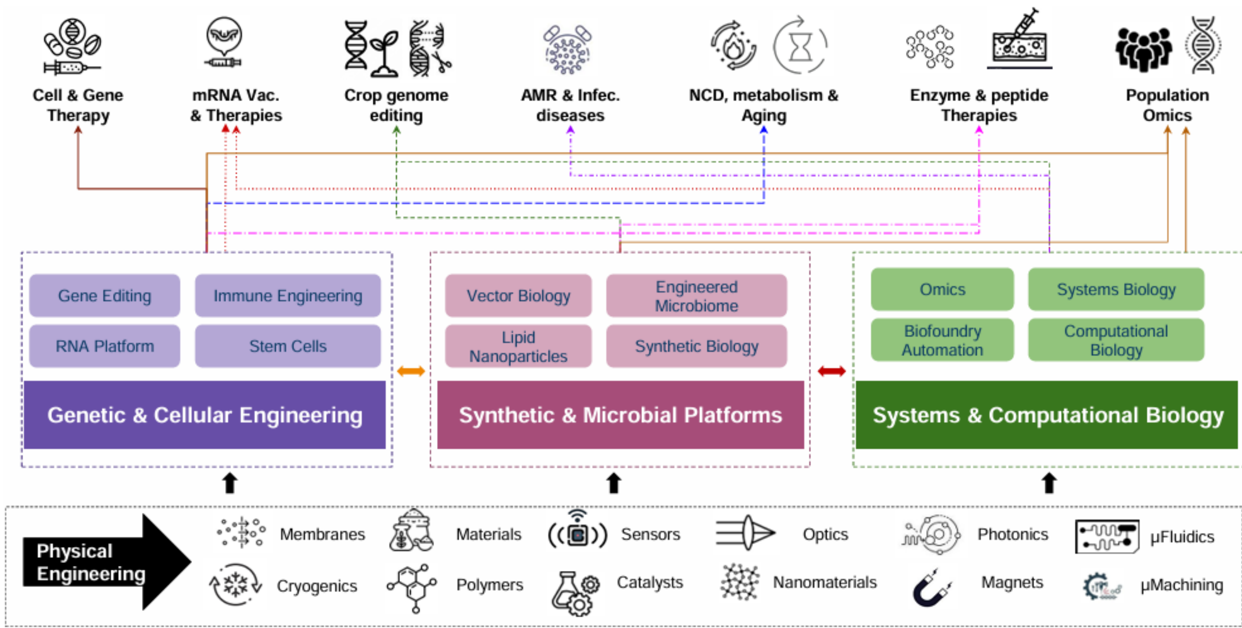
Technology Focus Areas

The proposed initiative focuses on building foundational capabilities, setting up industrial prototyping and commercial scale testing facilities, and integrating Industry 4.0 capabilities for process optimization, efficiency improvement, and process intensification. Depending on existing capabilities, it may be required only to augment the facilities available at the various Indian institutes. Annexure II shows the key indicative technology focus areas and sub-categories for India's proposed Translational Research Initiative to set up the translational research hubs/centres.

The Translational Research Centres (TRCs) are designed to be end-use agnostic, with technologies and innovations often having applications across multiple sectors. For instance, a TRC developing sustainable cooling solutions might address challenges such as heat stress, improve cold chain logistics for vaccines, and support energy-efficient infrastructure. Similarly, advancements in biotechnology from a TRC could contribute to health outcomes, environmental monitoring, or even sustainable agriculture. This approach underscores the interconnected nature of challenges and solutions, enabling these centres to drive impact across diverse domains.

Biological Engineering Translational Research Centres

ITRI has identified the following set of TRCs that will drive impact using innovations in biological engineering.



1. *Gene Editing*

Gene editing has rapidly transitioned from a novel concept to a defining and transformative tool within the field of biology. The unprecedented ability to precisely modify the genomes of organisms, ranging from microorganisms to plants and animals, unlocks the potential to manipulate genes for a diverse array of applications. This includes the development of climate-resilient crops, capable of withstanding extreme environmental conditions and ensuring food security, and the crucial effort to tackle the growing threat of antimicrobial resistance by engineering novel therapeutic strategies.

To accelerate the translation of these groundbreaking possibilities into tangible solutions, the establishment of a TRC dedicated to gene editing is essential. This TRC will serve as a central hub, providing researchers and industry professionals with accessible and cutting-edge tools and technologies related to gene editing. By democratizing access to these resources, the TRC will foster collaboration, streamline research workflows, and expedite the development of innovative technologies and applications. This initiative aims to bridge the gap between fundamental research and real-world implementation, ultimately fast-tracking the deployment of gene editing solutions to address pressing challenges in agriculture, medicine, and beyond.

2. mRNA platform

The messenger RNA (mRNA) platform is rapidly emerging as a revolutionary approach in therapeutics, offering a highly adaptable and promising method to leverage the body's intrinsic cellular machinery to produce therapeutic proteins and antibodies. Unlike traditional therapies that introduce external proteins or chemicals, mRNA technology delivers instructions directly to cells, prompting them to synthesize the desired proteins. This approach holds immense potential for treating a wide range of diseases, from infectious diseases and cancer to rare genetic disorders.

The concept of a 'configurable mRNA platform' is central to maximizing the impact of this technology. Such a platform would provide a standardized, yet flexible, framework for designing and manufacturing mRNA-based therapeutics. This modularity allows for the rapid adaptation of the platform to target different diseases by simply changing the mRNA sequence encoding the desired protein. This streamlined approach significantly accelerates the development timeline, enabling faster translation from research to clinical applications.

Furthermore, a configurable mRNA platform facilitates the establishment of standardized regulatory and production frameworks. This is crucial for ensuring the safety, efficacy, and scalability of mRNA-based therapies. By developing robust manufacturing processes and adhering to stringent regulatory guidelines, we can accelerate the commercialization of these life-changing treatments. This standardization also reduces the complexity and cost associated with developing new mRNA therapeutics, making them more accessible to patients worldwide.
The potential applications of a configurable mRNA platform are vast, encompassing Vaccines, Protein Replacement Therapies, Antibody Therapies, Gene Editing, and Regenerative Medicine.

3. Cell and Gene Therapy (CGT)

Cell and Gene Therapy (CGT) represents a revolutionary and rapidly advancing class of therapies poised to transform the landscape of medicine. These therapies offer the potential to address a broad spectrum of conditions, including historically intractable diseases such as rare genetic disorders, various forms of cancer, persistent infectious diseases, and the complex challenges of tissue repair and regeneration. This burgeoning field is characterized by its innovative approaches, which directly target the fundamental biological mechanisms of disease at the cellular and genetic levels.

At its core, CGT encompasses two primary modalities: gene therapy and cell therapy. Gene therapy involves the deliberate modification of a patient's genetic material to treat or prevent disease using Gene Replacement, Gene Inactivation, and Gene Introduction.

Cell therapy, on the other hand, focuses on the transplantation of healthy cells to replace damaged or dysfunctional cells within a patient. These cells can be derived from the patient themselves (autologous), minimizing the risk of immune rejection, or from a compatible donor (allogeneic). A prominent example of cell therapy is stem cell transplantation, which leverages the remarkable regenerative capacity of stem cells to repair damaged tissues and organs. This modality has shown promise in treating conditions such as leukaemia, lymphoma, and certain autoimmune diseases.

Furthermore, the field is witnessing the emergence of combined approaches, where cell and gene therapies are integrated to achieve synergistic therapeutic effects. For instance, a patient's own cells may be genetically modified ex vivo (outside the body) to enhance their therapeutic properties before being reintroduced. This strategy, exemplified by CAR T-cell therapy, has demonstrated remarkable success in treating certain types of cancer.

The development of CGT is driven by continuous advancements in areas such as gene editing technologies (e.g., CRISPR-Cas9), viral vector engineering, and stem cell biology. These innovations are enabling the creation of increasingly precise and effective therapies. This rapidly evolving field holds immense promise for revolutionizing medicine, offering the potential for durable and even curative treatments for a wide range of debilitating diseases.

4. cGMP and pilot facilities for Biopharma and Bioprocessing:

Biologic therapies, encompassing a wide range of treatments like monoclonal antibodies, cell and gene therapies, and vaccines, represent a frontier in modern medicine. However, their production demands stringent manufacturing and quality control regimes, adhering to Current Good Manufacturing Practice (cGMP) standards. These standards are crucial for ensuring the safety, efficacy, and consistency of these complex therapies.

The establishment of cGMP-compliant facilities is a capital-intensive undertaking, requiring specialized equipment, controlled environments, and highly skilled personnel. Consequently, these facilities often fall outside the financial scope of many critical contributors to medical innovation, including clinical researchers, start-up companies, and Micro, Small, and Medium Enterprises (MSMEs). These entities, while possessing invaluable research and development expertise, frequently lack the resources necessary to navigate the complexities of cGMP manufacturing.

To effectively advance the Technology Readiness Levels (TRL) of these promising therapies and accelerate their translation from bench to bedside, it is imperative that cGMP pilot facilities that support biopharmaceutical development be established in a centralized and accessible manner. This approach would create a shared resource, lowering the barriers to entry and enabling a broader range of stakeholders to participate in the development and production of biologic therapies.

A centralized and accessible cGMP facility would offer several key advantages:

- Reduced Financial Burden: By sharing the costs of infrastructure and equipment, researchers, start-ups, and MSMEs can focus their resources on innovation and research.
- Accelerated Development: Access to established cGMP facilities streamlines the manufacturing process, allowing for faster production of clinical trial materials and accelerating the pace of development.
- Enhanced Quality Control: Centralized facilities can maintain consistent quality control standards, ensuring the safety and reliability of biologic therapies.

- Knowledge Sharing and Collaboration: A shared facility fosters collaboration and knowledge exchange among researchers and industry professionals, promoting innovation and best practices.
- Streamlined Regulatory Pathways: Having access to a facility that already has experience navigating regulatory hurdles associated with cGMP manufacturing can greatly assist smaller companies.

In essence, establishing centralized and accessible cGMP facilities is crucial for democratizing access to biopharmaceutical manufacturing, fostering innovation, and ultimately, bringing life-saving therapies to patients more rapidly.

ITRI Backbone Services

1. National Omics Cluster

Omics technologies provide a comprehensive molecular understanding of organisms, crucial for biomarker discovery, therapy development, and biological engineering across diverse applications, from crop genome editing to cultured meat. Globally, centralized omics clusters are standard practice, offering high-quality data services to multiple institutions. This model, prevalent in the US and UK, is highly capital-efficient and effective compared to distributed, institution-specific platforms. A world-class, service excellence-oriented omics center in India could sustainably serve clinical, academic, startup, MSME, and international industry needs. Such a cluster can cost-effectively drive a wide variety of Indian omics studies such as cancer-omics, brain-omics, age-omics, and nutrigenomics among other such population-wide studies.

2. National Biobanking Network

Biobanks serve as indispensable repositories of biological samples, including tissues, blood, and other bodily fluids, along with associated data. These collections are vital for advancing research and discovery across a broad spectrum of human health and disease. By providing researchers with access to well-characterized and ethically sourced samples, biobanks enable the exploration of complex biological mechanisms and the identification of novel biomarkers and therapeutic targets.

The importance of accessible biobanks becomes particularly evident when considering the investigation of prevalent and debilitating human conditions. For instance, in cancer research, biobanks facilitate the study of tumor heterogeneity, the identification of genetic mutations driving cancer progression, and the development of personalized treatment strategies. In the field of aging research, biobanks contribute to understanding the molecular basis of senescence and the identification of interventions to promote healthy aging.

Neurological diseases, such as Alzheimer's, Parkinson's, and multiple sclerosis, pose significant challenges to researchers. Biobanks containing brain tissue and cerebrospinal fluid samples are crucial for unravelling the complex pathologies of these diseases and developing effective therapies. Similarly, the study of liver diseases, including hepatitis, cirrhosis, and liver cancer, benefits immensely from access to well-annotated liver tissue and blood samples.

The accessibility of biobanks to researchers is paramount. This accessibility should encompass not only physical access to samples but also the availability of comprehensive clinical and demographic data associated with each sample. This data enables researchers to perform meaningful analyses and draw robust conclusions. Moreover, standardized protocols for sample collection, processing, and storage are essential to ensure the quality and reproducibility of research findings.

To maximize the impact of biobanks, it is crucial to establish robust data management systems, implement ethical guidelines for sample collection and usage, and foster collaboration among researchers, clinicians, and biobank managers. By creating a collaborative and well-regulated biobanking infrastructure, we can accelerate the pace of scientific discovery and translate research findings into tangible benefits for human health.

3. Compute, Modeling, and AI infrastructure

The establishment of ITRI TRCs will inevitably necessitate substantial computing infrastructure. This infrastructure is essential for the development and training of sophisticated artificial intelligence (AI) models, which are increasingly integral to data analysis, pattern recognition, and predictive modeling within these domains. Moreover, these TRCs will require robust software platforms and high-performance computing capabilities to process and interpret the vast research datasets.

Recognizing the potential for redundancy and the inherent inefficiencies of distributed computing resources, ITRI will provide this essential infrastructure as a centralized backbone service to all its TRCs. This strategic approach offers several key advantages:

- Elimination of Redundancy: By consolidating computing resources, ITRI avoids the duplication of hardware and software investments across individual TRCs, leading to significant cost savings.
- Standardized Environment: A unified computing platform ensures consistency and interoperability across TRCs, facilitating data sharing and collaboration.
- Enhanced Security and Data Management: Centralized control over computing resources allows for the implementation of robust security measures and standardized data management protocols, ensuring the integrity and confidentiality of sensitive research data.
- Knowledge Sharing and Model Reuse: Perhaps most importantly, a centralized infrastructure enables ITRI to effectively share AI models and other computational resources developed by one TRC with other TRCs. This practice avoids the costly and time-consuming redevelopment of existing tools, accelerates research progress, and promotes cross-disciplinary collaboration.
- Efficient Resource Allocation: ITRI can dynamically allocate computing resources based on the real-time needs of each TRC, ensuring optimal utilization and minimizing idle capacity.
- Simplified Support and Maintenance: A centralized infrastructure simplifies system administration, maintenance, and troubleshooting, reducing operational overhead and ensuring consistent performance.

In essence, providing a centralized computing backbone service to its TRCs allows ITRI to optimize resource allocation, promote collaboration, and accelerate the development and deployment of AI-driven solutions across a wide range of research domains

4. *Centralized Procurement across TRCs:*

Considering ITRI's significant emphasis on establishing cutting-edge infrastructure, substantial capital investment in procuring diverse instrumentation across its various Technology Resource Centers (TRCs) will be necessary. This procurement will involve acquiring a wide array of specialized equipment, often in multiple quantities, from a range of vendors.

To optimize this substantial investment and ensure the most efficient use of resources, ITRI will implement a centralized strategy for collating the instrumentation requirements from all its TRCs. By comprehensively gathering and analyzing the collective needs of each TRC, ITRI will gain a clear understanding of the overall demand for specific instruments, reagents, and consumables.

This consolidated demand aggregation will create a powerful negotiating position for ITRI when interacting with vendors. This strategic approach will enable ITRI to:

- Negotiate Favorable Pricing: By purchasing instruments and consumables in volume, ITRI can leverage its collective buying power to secure significant discounts and reduce overall procurement costs.
- Establish Beneficial Arrangements: ITRI can establish strategic vendor partnerships and negotiate favorable terms and conditions with vendors, such as extended warranties, priority service, and customized training programs.
- Streamline Procurement Processes: Consolidating procurement activities simplifies logistics, reduces administrative overhead, and minimizes delays.
- Reduce Redundancy and Waste: By avoiding fragmented procurement, ITRI minimizes the risk of purchasing redundant equipment or overstocking consumables.

In essence, the centralized collation of instrumentation requirements will enable ITRI to optimize its capital expenditure, secure favorable terms with vendors, and establish a robust and efficient infrastructure that supports the advancement of its TRCs.

To enhance the efficiency of translational research, it is crucial to complement experiments with advanced digital and industry 4.0 technologies. These backbone services are essential for the following reasons:

- Supercomputers: Access to state-of-the-art supercomputers provides the necessary computing power to handle complex simulations and data analyses. This accelerates research timelines and enhances the accuracy of experimental models, leading to more reliable results.
- Simulation Software: Access to relevant simulation software allows researchers to model experiments accurately. This helps predict outcomes, optimize processes, and reduce the need for extensive physical trials, thus saving time and resources.
- Digital Twin: Creating digital twins for monitoring experiments enables real-time observation and control. Digital twins replicate physical processes in a virtual environment, facilitating better decision-making and creating optimized experiment designs (DOE).
- Relevant AI Models: Utilizing Physics Informed Neural Networks (PINN) and other advanced AI models enhances simulation accuracy and efficiency. These models can provide insights

that are not easily achievable through traditional methods, leading to innovative solutions and accelerated research progress.

- Efficient Data Management: Implementing software like Laboratory Information Management Systems (LIMS) ensures proper data collection, storage, and management. Efficient data management is vital for maintaining data integrity, facilitating collaboration, and enabling seamless access to research findings.
- Intellectual Property Management Certification: Achieving relevant ISO certifications around IP and data management is crucial for engaging with global industry partners. It assures potential collaborators and investors of the centre's commitment to maintaining high standards in managing intellectual property.
- Transparency: Establishing a centralized database and project tracking system enhances transparency and accountability. This system allows the industry to understand various technologies at the centres. It also extends its benefits to non-translational research centres, fostering a collaborative research environment.
- Assembly Automation Prototype: Developing a versatile setup with various automation tools for assembly lines is essential for creating world-class manufacturing technologies. This setup allows industrial automation companies to test their tools and manufacturers to evaluate process efficiency. This mutual benefit accelerates the development and adoption of advanced manufacturing technologies.

Strategies for Enhancing Translational Research Success

- Philanthropic and Financial Strategies
  - **Naming Rights:** Utilizing naming rights as a strategic tool to attract philanthropic capital, offering companies significant visibility and recognition while fostering a strong funding ecosystem for thematic centres.
- Talent Development and Retention
  - **Attracting Global Talent:** Establishing India as an attractive hub for international scientific excellence by fostering a conducive environment for global researchers and innovators.
    - ***ITRI Fellowship Program***: ITRI is planning to establish the **ITRI Fellowship Program** as part of its initiative to strengthen India's translational research ecosystem. The program envisions attracting and nurturing exceptional talent to address the critical shortage of skilled researchers in advancing technologies through TRL 5-7. By embedding fellows in the Translational Research Centres (TRCs) of host institutes, ITRI aims to bridge the gap between academic innovation and industrial application, fostering a continuum of research that translates ideas into scalable, impactful solutions. This fellowship is expected to play a pivotal role

in building a sustainable talent pipeline, ensuring continuity in research efforts while fostering a culture of innovation and practical problem-solving. ITRI plans to provide fellows with structured mentoring, access to cutting-edge facilities, and opportunities for collaboration with industry partners, equipping them to lead impactful research. The program will also incorporate governance mechanisms to monitor fellows' progress, including periodic reviews and structured reporting frameworks, ensuring alignment with ITRI's vision. By addressing the talent gap, the fellowship aspires to create a robust foundation for India's self-reliance in high-priority technology domains and to drive a transformative impact on the nation's translational research capabilities.

- **Talent Continuity:**
  - ***Entrepreneurs in Residence (EiR) program***: Institutionalizing structures such as Entrepreneurs in Residence (EiR) programs, enabling researchers to continue contributing to translational projects. This continuity simplifies the technology development journey and ensures smoother transitions from research to commercialization.

- Operational Efficiency and Infrastructure
  - **Streamlined Procurement Processes:** Simplifying the procurement of critical equipment to enhance operational efficiency and reduce delays in research workflows.
  - **Land and Building Development:** Ensuring the timely acquisition of land and construction of infrastructure necessary to support cutting-edge research initiatives.

- Technology and Transparency
  - **Digitization and Transparency:** Implementing a central tracking system for monitoring the commercialization of innovations. A dedicated technology evaluation and adoption team will oversee this system to ensure transparency, efficiency, and accountability throughout the innovation lifecycle.

- Global Collaboration and Learning
  - **Incorporating Global Best Practices**: Learning from successful translational research models in countries such as Germany, Israel, the UK, and the US. Adapt their strategies to Indian contexts to strengthen the research ecosystem and achieve international standards.

Governance

The governance mechanism of the ITRI is designed to ensure robust oversight, accountability, and operational efficiency. It employs multiple layers of monitoring to oversee the Translational

Research Centres (TRCs) and associated projects, as well as to manage backbone services critical to translational research.

Key Layers of Governance and Monitoring:

Host Institution-Level Governance:

- ITRI will leverage and augment the existing governance mechanisms of host institutions by utilizing their established committees to oversee TRCs and the projects they house.
- These committees will include sectoral academic and research experts and will establish Grants Committees to evaluate, approve, and monitor translational research projects.
- Regular reviews at this level will ensure projects align with institutional goals and national priorities.

ITRI Level Governance:

- A Core Committee at the ITRI level will coordinate with the host institution committees of each TRC, establishing an effective governance mechanism to oversee progress and ensure strategic coherence.
- ITRI will develop and manage a central database to enhance transparency, enable real-time progress tracking, and foster knowledge sharing across centres.
- Shared backbone services will be centrally monitored by ITRI to ensure accessibility and optimal use across TRCs.
- The ITRI fellowship will be an integral component of ITRI's governance framework, with mechanisms to monitor fellows' contributions and align their research goals with commercialization pathways. This structure will ensure that fellows not only focus on research but also actively engage in market validation, prototype development, and industrial collaborations, accelerating the journey from lab to market.
- Stakeholder review panels to incorporate diverse perspectives and improve decision-making processes.
- Cross-TRC working groups to promote collaboration and interdisciplinary innovation.

Commercialization

At the India Translational Research Initiative (ITRI), we envision driving commercialization through a multifaceted approach that integrates technology licensing, industry partnerships, and entrepreneurship-focused programs. In the future, we aim to leverage a robust network of industrial collaborators to facilitate the seamless transfer of innovations from lab to market. Our planned Entrepreneurship in Residence (EiR) program will nurture scientist-entrepreneurs, supporting them in developing spinouts and creating a pipeline of high-impact startups.

Additionally, we plan to augment and complement the existing mechanisms at host institutes for patenting, prototype development, and validation, ensuring that innovations achieve market readiness. To address critical gaps, we will provide targeted funding for scale-up and expand access to state-of-the-art testing facilities. By aligning these efforts, we aim to ensure that breakthrough technologies progress efficiently towards widespread adoption, delivering significant societal and economic benefits. Furthermore, we plan to create structured pathways for engaging with global markets and fostering cross-border collaborations to scale innovations addressing India's and the world's most pressing challenges. This vision underscores our commitment to transforming India into a global hub for impactful translational research and innovation.

Key Stakeholders

Translational research in India involves diverse stakeholders, each crucial in advancing research from the lab to the market. Key players include universities, research institutes, innovation hubs, corporate innovation hubs and competence centres, incubators, accelerators, equipment suppliers, operators/manufacturers, and IP management organizations. Their collaborative efforts and shared resources help bridge the gap between basic research and practical applications, fostering an environment conducive to innovation and commercialization.

For most of the proposed centres, it is essential to engage three types of corporates:

- Equipment Providers: Each center will require numerous high-end and specialized pieces of equipment. It is crucial to engage with equipment manufacturers and involve them closely in the centre’s development from the early stages. Since the commercialization of technologies developed at the center can lead to significant business opportunities for these companies and increased visibility in the research community, this should incentivize them to engage proactively.
- Users of the Centres: Corporates operating in fields aligned with the centre’s translational research will be vital partners. These corporates will be interested in expanding their offerings by collaborating on the latest technologies being developed, with the potential to commercialize them. This initiative allows them to improve their production capabilities, collaborate with researchers to develop new technologies, and gain access to emerging markets.
- End-application Users: Corporates that will be the end users of the technologies developed by the center are also important partners. They can provide defined problem statements based on their performance requirements and may offer offtake guarantees, which can be foundational for the commercialization business model.

For each center, a target of partnering with 5-6 corporates, including at least one from each category mentioned, should be set. Apart from the corporates, each centre’s relevant stakeholders must be consulted to form strategic collaborations.

Fundraising

We propose a comprehensive framework to attract and sustain private capital, with a focus on philanthropic contributions as a cornerstone of funding for translational research centres. By presenting this initiative as a cohesive, nationwide effort rather than a collection of fragmented projects, we aim to highlight its transformative potential and broad societal impact, thereby making it more compelling to donors and investors.

Key Proposals**:**

1. **Leveraging Naming Rights**: We propose using naming rights as a strategic incentive to attract philanthropic capital. This approach provides significant visibility and recognition for foundational donors, positioning them as pivotal supporters of innovation. Additionally, we recommend offering transparency regarding the use of public funds to complement these contributions, providing philanthropists with confidence in the initiative's long-term sustainability.

2. **Mobilizing Corporate CSR Contributions**: Corporate CSR funding represents a significant opportunity, particularly from companies with strategic interests aligned with the centres' thematic focus. We propose engaging such stakeholders through targeted outreach and partnerships, ensuring their contributions directly support foundational infrastructure and programmatic goals.

3. **Industrial Projects as Long-Term Revenue Streams**: To ensure the sustainability of the centres, we recommend structuring opportunities for industry collaborations and commissioned research. These projects can serve as a steady revenue stream, covering operational costs once the centres are fully established. However, this transition to self-sustainability will require a phased approach, with initial reliance on philanthropic and public funding.

4. **International Collaborations**: We propose building partnerships with leading global academic and translational research institutions. These collaborations can provide not only additional funding but also access to expertise, shared infrastructure, and best practices, enhancing the global competitiveness of our centres.

5. **Public-Private Co-Funding Mechanisms**: To instil confidence among private investors, we propose public funding agencies adopt a co-funding or risk-sharing approach. This demonstrates a strong commitment from public stakeholders, creating a collaborative funding ecosystem that fosters partnerships and scales impact.

Key Next Steps

Align on Proposed Centres and Focus Areas	Define the objectives and specific research areas for each proposed translational center.

Map and Evaluate Suitable Institutes	Identify institutes capable of housing the proposed centres, considering both new setups and augmentation of existing facilities.
Request for Proposals from the Institutes	Solicit proposals from shortlisted institutes, providing a detailed list of questions to guide their submissions.
Capability Assessment through Institute Visits	Conduct on-site visits to assess the capabilities and readiness of the institutes firsthand.
Map Corporate Partners	Identify and map potential corporate partners relevant to each centre's focus areas.
Identify Philanthropists	Create a targeted list of philanthropists for engagement and potential funding.
Finalize Budget	Determine the overall budget
Launch the Initiative	Launch the initiative with support and endorsement from prominent Indian scientists like Prof. R. A. Mashelkar. It would be ideal for the Hon. Prime Minister of India to launch the initiative.
Engage Stakeholders	Actively engage with corporates and philanthropists post-launch to secure the necessary capital.

Vision for the Next 5 Years

The vision for ITRI over the next five years encompasses two key aspects: building a robust innovation ecosystem and contributing to nation-building. ITRI aims to establish foundational centres across critical sectors, serving as hubs for innovation and industrial research. These centres will accelerate the commercialization of over 50 innovative technologies, bridging the gap between research and market deployment. By fostering shared infrastructure and services, ITRI seeks to ignite a ripple effect, driving entrepreneurship, industrial growth, and economic development while positioning India as a global leader in innovation.

Annexure I

About Spectrum Impact

'Spectrum Impact' is the family office of Mr. Rajendra and Mrs. Arti Gogri, promoters of Aarti Industries Ltd., a listed specialty chemical company. The objective of the family office is to allocate capital through a broad spectrum of areas, such as investing in and supporting technologies and businesses that are working towards arresting and reversing climate change, as well as businesses and organizations working towards making health and education more accessible and affordable.

The family office has significantly invested globally in areas of nuclear fusion, nuclear fission, direct lithium extraction, energy-efficient appliances, carbon nanotubes, next-generation food technologies, bioenergy, plastics circularity, tipping point research, green hydrogen, carbon capture, and low carbon cement. Spectrum Impact and the broader Gogri family gave a grant to IIT B to establish the translation research center for Membranes.

Apart from capital deployments, Spectrum Impact also has initiatives to catalyze broader collaboration in the areas of climate and technology.

Mirik Gogri

Mirik leads Spectrum Impact, the family office of one of the promoters of Aarti Industries, which is dedicated to investing in innovative climate solutions. Under his leadership, Spectrum Impact deployed capital to over 70 organizations worldwide through a diverse investment strategy that includes grants, equity, and debt financing.

As the Head of Corporate Strategy at Aarti Industries Limited (AIL), Mirik plays a pivotal role in shaping the company's vision, particularly in driving innovation. Under his leadership, AIL has emerged as a beacon of excellence, with a deep-rooted focus on research and technology. Mirik's vision for AIL has led to establishing the world-class R&D center boasting over 250 scientists and engineers, demonstrating his dedication to pushing the boundaries of sustainable practices within the industry.

Mirik's alma mater, IIT Bombay, where he earned a dual graduate degree in Metallurgical Engineering and Material Science, laid the foundation for his keen interest in exploring sustainability and the evolving climate landscape.

Annexure II

Table 1. Key technology focus areas and potential applications for the proposed initiative

*(In the Sl. No. F stands for Foundational, P stands for Industrial Prototyping, and T stands for Testing to demarcate the **50** facility types below)*

Sl. No.	Focus Area	Type of TRC	Description	Potential Applications	Key Equipment / Facilities
F1	Membranes	Foundational	Key technology in Health, Energy, and Water. The center at IITB will have the equipment to produce various membranes and downstream products at a pilot scale.	Health Energy Water Membrane Manufacturers	Membrane fabrication units, Pilot-scale production lines
F2	High-performance ceramics	Foundational	Used in defense, sensors, and space due to heat resistance and abrasion properties. The center will have manufacturing and testing equipment.	Defense Sensors Space	High-temperature kilns, Abrasion testing apparatus
F3	Advanced metallurgy	Foundational	Develop new alloys, including high entropy alloys, with facilities for metallurgical processes like sintering and quenching. Applications include magnets, especially for industrial and EV motors.	Magnets Aerospace Automotive Companies	Alloy production units, Sintering, and quenching equipment
F4	2D materials	Foundational	Includes materials like Graphene and boron nitride nanosheets. The center will have manufacturing technologies and characterization equipment for these materials.	Electronics Composites Cell and Battery Manufacturers	Graphene production lines, Characterization equipment
F5	Engineering polymers and composites	Foundational	Develop polymers with niche properties and convert them into specific products. The center will have a polymerization lab and a composite lab.	Automotive Aerospace Electronics	Polymerization lab, Composite lab
F6	High-temperature superconductors	Foundational	Manufacture HTS tapes and develop applications like efficient generators and MRI machines.	Energy Medical Devices Industrial equipment producers	HTS tape production equipment, Application development lab

Sl. No.	Focus Area	Type of TRC	Description	Potential Applications	Key Equipment / Facilities
F7	Advanced separations technology	Foundational	Chemical separations center with technologies like divided wall columns and continuous crystallizers for cleaner technologies.	Chemical Pharmaceutical Environmental	Divided wall columns, Continuous crystallizers
F8	Advanced reactors	Foundational	Develop efficient chemical transformations with advanced reactor setups like fixed bed and membrane reactors.	Chemical Energy Pharmaceutical	Fixed bed reactors, Membrane reactors
F9	Catalyst (Precious metals)	Foundational	Focus on producing, recycling, and recovering precious metal catalysts for various applications.	Chemical Environmental firms Energy	Catalyst production units, Recycling facilities
F10	Catalyst (Zeolites and others)	Foundational	Study and produce zeolites, organic, and biocatalysts in pilot quantities.	Chemical Pharmaceutical Environmental technology providers	Zeolite production units, Biocatalyst labs
F11	Nanomaterials	Foundational	Produce and characterize nanomaterials and create stable dispersions for transportation.	Electronics Medicine Cell and Battery Manufacturers	Nanomaterial production units, Characterization equipment
F12	Adsorption center	Foundational	Deploy pilot-scale adsorption technologies for DAC, CCS, dehumidification, and efficient HVAC applications.	Environmental HVAC Energy	Adsorption technology units
F13	Supercritical processes	Foundational	Use supercritical fluids for applications like thermal energy conversion and extraction. The center will handle pilot-scale conditions.	Chemical Pharmaceutical, Food processing Textile	Supercritical fluid systems
F14	Optics	Foundational	Precision engineer high-end refractive and reflective optics for lasers, EUV lithography, and sensors.	Lasers, Lithography, Sensors	Precision engineering tools

Sl. No.	Focus Area	Type of TRC	Description	Potential Applications	Key Equipment / Facilities
F15	Electron Beam applications	Foundational	Machines like gyrotrons and klystrons are produced for fusion, food irradiation, and rock pulverization applications.	Nuclear Fusion, Food Processing, Mining	Electron beam generation equipment
F16	Corrosion and coating technology	Foundational	Test materials for corrosion properties and develop new coating technologies.	Industrial Construction companies, Marine technology providers	Corrosion testing units, Coating technology labs
F17	Sensors	Foundational	Manufacture and test high-quality sensors for Industry 4.0 and IoT to reduce import dependence.	Industrial Electronics Automation	Sensor manufacturing units, Testing equipment
F18	Aerogels	Foundational	Produce different types of Aerogel products using different processes and test them for application towards cold storage and biomedical-sensitive shipping	Industrial Cold Storage Logistics Pharmaceuticals	Supercritical Drying, Autoclaves, Microwaves, Testing equipment
F19	Microfluidics	Foundational	Research in manipulating fluids at the microscale for applications in diagnostics, drug delivery, and biosensing.	Drug delivery, diagnostic devices, biosensors, food safety, environmental monitoring	Microfabrication facilities, clean rooms, micro-pumps, sensors, optical microscopy
F20	Cryogenics	Foundational	Focuses on extremely low temperatures for advancements in quantum computing, medical imaging, and space technologies.	Quantum computing, medical imaging (MRI), space exploration, particle accelerators, low-temperature physics	Cryostats, MRI machines, superconducting magnets, dilution refrigerators, helium recovery systems
F21	Additive manufacturing	Foundational	Involves creating 3D-printed components for industries like aerospace, healthcare, and automotive sectors.	Aerospace components, medical implants, automotive parts, prototyping,	3D printers (metal/plastics), CAD software, laser sintering machines, material

Sl. No.	Focus Area	Type of TRC	Description	Potential Applications	Key Equipment / Facilities
				energy-efficient construction	characterization labs, post-processing units
F22	RNA Therapeutics	Foundational	RNA therapeutics involve using RNA molecules to treat or prevent diseases by targeting genetic pathways or cellular mechanisms. These therapies include mRNA-based treatments, siRNA (small interfering RNA) and shRNA (short hairpin RNA), miRNA (microRNA), ASO (Antisense Oligonucleotides), RNA editing and aptamers. RNA therapeutics provide an efficient, targeted, and versatile platform for treating diverse diseases, including genetic disorders, cancers, and infectious diseases.	Vaccines, Genetic Disorders, Cancer, Personalized Medicine, Immune Modulation, Neurological Disorders, Cardiovascular Diseases	Automated RNA synthesizers High-performance liquid chromatography (HPLC) Capillary electrophoresis systems Electroporation devices Robotic liquid handlers X-ray crystallography Cryo-electron microscopy
F23	Lipid nanoparticles	Foundational	Develops nanoparticles for drug delivery systems, including mRNA vaccines and cancer therapies.	Vaccine delivery (mRNA), cancer therapies, gene therapies, cosmetics, food science	Nano-formulation labs, particle size analyzers, ultracentrifuges, lipid extraction systems, sterilization equipment
F24	Textiles	Foundational	Research into smart fabrics, eco-friendly materials, and high-performance textiles for medical, industrial, and consumer applications.	Smart fabrics, wearable tech, medical textiles, eco-friendly fabrics, high-performance sportswear	Looms, fiber analysis tools, fabric testing machines, coating units, 3D weaving equipment
F25	Lasers	Foundational	Focuses on laser technologies for medical devices, material processing, communication, and defense.	Optical communication, material processing, medical devices (laser surgery), defense applications, sensors	Laser labs, optical fibers, laser beam analyzers, spectrometers, high-precision CNC machines

Sl. No.	Focus Area	Type of TRC	Description	Potential Applications	Key Equipment / Facilities
F26	High-energy particle therapy	Foundational	Involves particle accelerators for cancer treatment, imaging, and material science research.	Cancer treatment, imaging technologies, material science, nuclear research, space applications	Proton accelerators, particle beam delivery systems, dosimetry systems, radiation shielding, treatment planning software
F27	High entropy materials	Foundational	Studies complex alloys for applications in aerospace, automotive, and energy storage systems.	Aerospace, automotive, defense, energy storage, construction	Material synthesis labs, mechanical testing devices, thermal analysis equipment, X-ray diffraction machines, scanning electron microscopes
F28	Genetic Technologies	Foundational	Gene-editing research aimed at developing precision medicine, disease-resistant crops, and genetic therapies.	Gene editing, disease-resistant crops, precision medicine, therapeutic developments, livestock breeding	Gene editing tools, CRISPR libraries, PCR machines, DNA sequencers, cell culture labs
F29	Magnets	Foundational	Research on advanced magnetic materials for energy generation, electric motors, and data storage technologies.	Electric motors, magnetic storage devices, medical imaging, aerospace, power generation	Magnetometers, superconducting magnets, coil winding machines, cryogenic chambers, material characterization tools
F30	Nanopores	Foundational	Develops nanopore technology for rapid DNA sequencing, biosensing, and drug delivery.	DNA sequencing, biosensing, water purification, drug delivery, electronics	Nanopore sequencing devices, microfluidic chips, nanoparticle analyzers, AFM/SEM microscopes, bio-sample preparation tools
F31	Metamaterials	Foundational	Studies engineered materials with unique properties for applications in optics, antennas, and stealth technology.	Superlenses, stealth technology, antennas, medical imaging, energy harvesting	RF testing equipment, 3D printers for metamaterials, waveguides, anechoic chambers, terahertz imaging systems

Sl. No.	Focus Area	Type of TRC	Description	Potential Applications	Key Equipment / Facilities
F32	Biocompatible materials	Foundational	Focuses on materials that integrate with biological systems for implants, tissue engineering, and drug delivery.	Medical implants, tissue engineering, drug delivery, wound healing, prosthetics	Bioprinting systems, mechanical testing equipment, chemical synthesis labs, sterilization units, cell culture incubators
F33	Low carbon steel	Foundational	Develops sustainable steel solutions for the construction, automotive, and energy sectors.	Sustainable construction, automotive industry, energy infrastructure, shipbuilding, pipelines	Steel processing mills, high-temperature furnaces, tensile testing machines, electron microscopes, corrosion testing facilities
F34	Stem Cells	Foundational	Use of multiple sources of stem cells for treatment of diseases of multiple systems	Cellular therapies, cardiovascular diseases, blood disorders, disease modeling, gene editing, tissue engineering, regenerative medicine	FACS, MACS, cell labelling techniques, culture equipment, microscopy, storage, molecular biology equipment, biosafety equipment, quarantine equipment
F35	Cell Therapy	Foundational	Cell therapy involves the administration of live cells to repair, replace, or enhance the biological function of damaged tissues or organs. These therapies can be autologous (derived from the patient) or allogeneic (from a donor) and often utilize genetically engineered or expanded cells.	Cancer Treatment, Regenerative Medicine, Autoimmune and Inflammatory Diseases, Genetic and Metabolic Disorders	Flow cytometers Magnetic-activated cell sorters (MACS) Bioreactors Viral vector production systems Imaging systems
P1	Biotech Piloting facility	Industrial Prototyping	Scale biotransformations for high-volume end use with large-scale fermentors and downstream facilities.	Biotechnology Agriculture Pharmaceuticals	Large-scale fermentors, Downstream processing facilities
P2	BioPharma piloting facility	Industrial Prototyping	GMP facility for piloting biopharma production, addressing the growing market for biomolecules in pharma.	Pharmaceuticals Biotechnology Healthcare	GMP production facility

Sl. No.	Focus Area	Type of TRC	Description	Potential Applications	Key Equipment / Facilities
P3	Cement decarbonization	Industrial Prototyping	A center of excellence with pilot-scale technologies to accelerate decarbonization in the cement sector.	Construction Environmental Industrial	Pilot-scale cement production technologies
P4	Industrial scale metal working	Industrial Prototyping	Prototype metal working operations like forging and casting for various industries.	Automotive Aerospace Construction	Forging and casting equipment
P5	Mold creation	Industrial Prototyping	Versatile mold-making facility for industries, especially packaging, to accelerate prototyping.	Packaging Industrial Manufacturing	Mold-making machines
T1	Electrolyzer assembly & testing facility	Testing Facility	Test electrolyzers on a 100kW to 1MW scale to aid in commercializing low-carbon technologies in the future.	Energy Chemical Environmental	Electrolyzer testing units
T2	Solar module testing facility	Testing Facility	Test and compare various solar technologies to aid deployment and validation.	Energy Technology	Solar module testing equipment
T3	Battery testing line	Testing Facility	Prototype new battery chemistries and architectures with a demo manufacturing line and testing facilities.	Energy storage Automotive Electronics	Battery manufacturing line, Testing equipment, Low humidity space
T4	Wind tunnel testing	Testing Facility	Develop reliable products with a high-capacity wind tunnel for large objects and high wind speeds.	Aerospace Automotive Industrial	High-capacity wind tunnel
T5	Bioenergy testing	Testing Facility	A pilot facility will be used to test and compare biomass types for energy and biogas generation.	Energy Environmental Agriculture	Biomass testing units
T6	Water treatment	Testing Facility	Test and compare various wastewater treatment technologies, including industrial wastewater solutions.	Environmental firms Industrial Municipal authorities	Wastewater treatment equipment

Sl. No.	Focus Area	Type of TRC	Description	Potential Applications	Key Equipment / Facilities
T7	Ocean related technologies	Testing Facility	Pilot platform for sea-related technologies like Ocean Thermal Energy Conversion (OTEC), wave power, and offshore wind.	Energy Marine Environmental	Ocean technology platforms
T8	Agriculture input field testing	Testing Facility	Test and compare new agricultural products like nano fertilizers and precision agriculture.	Agriculture Biotechnology Environmental	Agricultural testing facilities
T9	Agriculture equipment testing	Testing Facility	State-of-the-art facility to test new irrigation, harvesting, and seeding machines.	Agriculture Technology Industrial	Equipment testing units
T10	Steel testing facility	Testing Facility	A steel testing facility is equipped to evaluate the mechanical, chemical, and physical properties of steel to ensure its compliance with industry standards and application requirements. These tests assess steel's strength, ductility, hardness, toughness, and corrosion resistance, as well as its microstructure and chemical composition. Such facilities are essential in quality control, research and development, and failure analysis in various industries, including construction, automotive, aerospace, and manufacturing.	Quality Control in Steel Production, construction, automotive and aerospace, shipbuilding and marine applications, pipeline and energy industries, failure analysis	Mechanical testing equipment, chemical analysis tools, corrosion testing equipment, NDT facilities, heat treatment and simulation systems, etc.