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CONFERENCE REPORT

Leveraging Space to Speed Up Pharmaceutical Research in India

17 March 2026

PREPARED BY

MERI Department of Space Studies & SIA-India

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EXECUTIVE SUMMARY

The "Leveraging Space to Speed Up Pharmaceutical Research in India" conference, held on March 17, 2026, at the MERI Delhi Campus, explored the convergence of space technology and the pharmaceutical sector. As the International Space Station (ISS) nears decommissioning in 2031, a critical window has opened for India to transition from a generic manufacturing hub to a high-value innovation leader by leveraging microgravity for drug discovery. Key challenges identified include high launch costs, significant physiological impacts of long-duration spaceflight on astronauts, and the need for new regulatory standards like "Orbital Good Manufacturing Practice" (OGMP). Major recommendations include establishing a national coordination platform, investing in reusable space plane infrastructure for faster cargo return, and fostering ISRO-AIIMS collaborations for deep-space health monitoring.

1. Background and Context

(a) Health care and Pharma in India: Current Challenges

(i) Innovation Gap: India currently focuses heavily on cost-based generic manufacturing rather than high-value drug innovation.

(ii) Infrastructure Decommissioning: The impending retirement of the ISS in 2031 creates an urgent need for new orbital research platforms.

(iii) Terrestrial Limitations: Gravity-driven convection and buoyancy on Earth often lead to flawed protein crystallization, limiting the development of highly effective biologics.

2. The Role of Space Technology in Pharmaceutical Research

(a) Microgravity Benefits: In microgravity, protein crystals grow more slowly and align more perfectly, providing superior data for drug design.

(b) Breakthrough Applications: Space enables advanced 3D bio printing of organs without scaffolds, superior monoclonal antibody production, and accelerated cancer research using tumor organoids.

3. Policy Context

(a) Vision 2035: India aims to establish the Bharat Antariksh Station by2035 as a hub for orbital manufacturing and research.

(b) Strategic Alignment: The mission aligns with national goals to integrate space technology into the national health agenda to maintain a global leadership position.

4. Health Perspectives and Space Realities

(a) Physiological Challenges

(i) Cardiovascular & Fluid Shifts: Microgravity causes a 12-15% reduction in blood volume and significant upward fluid shifts ("puffy face" syndrome).

(ii) Musculoskeletal Atrophy: Long duration missions lead to bone density loss and muscle deterioration, requiring countermeasures like Myostatin inhibitors.

(b) Dermatological and Immune Issues

(i) Skin Thinning: Astronauts experience up to 20% skin thinning and 25x higher incidence of skin rashes.

(ii) Immune Suppression: Space environments cause immune changes and viral reactivation, necessitating robust pharmaceutical support.

(c) Pharmacokinetic Constraints

(i) Absorption Delay: Upward fluid shifts slow gastric emptying, delaying the absorption of oral medications in space.

(ii) Stability: Cosmic radiation can break covalent bonds in medicine, leading to potency loss and toxic by-products.

5. Technology Transforming Indian Pharma

(a) Orbital Labs and Protein Crystallization

(i) Superior Crystals: Space-grown crystals, such as Bovine Insulin, show much higher structural perfection compared to Earth-grown versions.

(ii) Case Study: Merck's Keytruda was reformulated in space from a long IV infusion to a simple single injection through microgravity-enabled crystallization.

(b) Bio manufacturing and 3D Bio Printing

(i) Scaffold-free Printing: Microgravity allows for 3D bioprinting of complex tissues and organs without the need for structural scaffolds required on Earth.

(ii) Stem Cell Research: Space environments are being used to study "dark genome" activation and develop cancer stem-cell inhibitors.

(c) Advanced Drug Delivery and Stability

(i) Nanotechnology: Use of lipid-based nano-encapsulation to protect APIs from cosmic radiation and oxidative stress during long missions.

(ii) 3D Printed Meds: Developing on-demand, customized drug printing to eliminate large perishable stockpiles for deep-space missions.

(d) Digital Platforms and AI Integration

(i) Digital Twins: Integrating AI and digital twin technologies to monitor astronaut health and predict drug stability in real-time.

(ii) Remote Labs: Development of automated "Labs-on-a-Chip" for real-time, remote-controlled orbital experiments.

(e) Reusable Infrastructure

(i) Space Planes: Reusable space plane solutions (e.g., AnduraX) aim to reduce cargo recovery times from 16 hours to just 2 hours with <1.5G reentry.

(f) Bridging the Technology - Adoption Gap

(i) Standardization: Establishing Orbital Good Manufacturing Practice (OGMP) standards is essential to regulate pharmaceutical production in orbit.

(ii) Public-Private Partnerships: Deepening collaborations to reduce the 12-24 month wait time for research.

6. Policy Recommendations

Category	Key Recommendations	Responsible Entities	Timeline
Regulatory Framework	Establish Orbital Good Manufacturing Practice (OGMP) standards for drug production in space; develop validation protocols for microgravity - based pharmaceuticals; create fast-track. Approval pathways for space-derived drugs	CDSCO, ISRO, ICMR, Ministry of Health	Short Term (1–2 years)
Space Pharma Infrastructure	Develop orbital laboratories ("Dark Labs") for autonomous drug research; invest in Bharat Antariksh Station as a pharma research hub; create dedicated payload capacity for pharma experiments	ISRO, IN-SPACe, Private Space Firms	Medium Term (3–5 years)
Research & Innovation	Fund microgravity-based drug discovery programs; promote interdisciplinary R&D combining pharma, biotech, and space science; incentivize universities to establish space health research centers	DST, DBT, Universities, Research Institutes	Ongoing
Public–Private Partnerships (PPP)	Strengthen collaboration between ISRO, AIIMS, biotech startups, and pharma companies; create joint innovation platforms; reduce research wait times through shared infrastructure	ISRO, AIIMS, Private Pharma Firms	Short to Medium Term
Healthcare Systemsfor Space	Develop integrated astronaut healthcare systems using AI, wearable devices, and telemedicine; standardize protocols for long-duration missions	ISRO, ICMR, DRDO, Health Tech Firms	Medium Term (2–4 years)
Drug Stability & Packaging	Invest in radiation-resistant packaging and nano-encapsulation technologies; develop compact, multi-functional drug formulations for space missions	Pharma Companies, DRDO, Research Labs	Short to Medium Term
Digital & AI Integration	Implement digital twin systems for real-time monitoring of astronaut health; deploy AI for predicting Drug stability and physiological changes	ISRO, Tech Companies, Startups	Short Term (1–3 years)
Reusable Space Logistics	Promote development of reusable space planes for faster sample return; reduce down mass time for pharmaceutical experiments	ISRO, Private Aerospace Firms	Medium Term (3–5 years)
Capacity Building & Skill Development	Introduce training programs in space medicine, astro-pharmacy, and bioengineering; develop specialized academic curriculum	Universities, ISRO, Medical Institutes	Ongoing

International Collaboration	Partner with global space agencies and pharma companies for joint missions and knowledge exchange; participate in global Regulatory standard-setting	ISRO, Ministry of External Affairs	Long Term (5+ years)
Funding & Incentives	Provide grants, tax incentives, and venture funding support for startups in space pharma; create dedicated innovation funds	Government, NITI Aayog, Venture Funds	Short Term
Ethics & Safety Governance	Develop ethical guidelines for human testing in space; ensure safety standards for astronauts and experimental subjects	ICMR, CDSCO, International Bodies	Medium Term

7. Conclusion

The conference concluded that India is uniquely positioned to lead the "Space- Pharma" era. By integrating space-based research into the national health agenda and establishing necessary regulatory frameworks like OGMP, India can transition into a global leader in high-value pharmaceutical innovation**.**

Dimension	Key Insights	Impact
Scientific Breakthroughs	Protein crystallization, cancer apoptosis, 3D bioprinting	Faster and more precise drug development
Human Health	Bone loss, muscle atrophy, immune suppression	Need for specialized space healthcare
Orbital Economy	Dark labs, private space stations	Emergence of new pharma markets
India’s Strategy	Gaganyaan, AI integration, OGMP	Global leadership opportunity

Preface

We are living in a time where the boundaries of science are expanding beyond Earth, and with it, the way we understand health, medicine, and innovation is also evolving. What once seemed like science fiction - conducting research in space, developing medicines in microgravity, and managing human health beyond our planet - is now becoming a tangible reality.

The conference on “Leveraging Space to Accelerate Pharmaceutical Research & Space Health Systems” reflects this shift. It brings together experts from diverse fields - space science, medicine, pharmaceuticals, and industry -to explore how the extreme conditions of space can unlock new possibilities for humanity. From improving drug development processes to rethinking healthcare systems for astronauts, the discussions highlight both the immense potential and the complex challenges of this emerging domain.

At its core, this report is not just about technology or space missions. It is about people- the scientists pushing the boundaries of knowledge, the innovators building new systems, and the future astronauts who will rely on these advancements for survival. It also reflects a broader vision: that the solutions developed for space can significantly improve life on Earth, making healthcare more efficient, resilient, and inclusive.

As India moves forward with ambitious initiatives like the Bharat Antariksh Station and expands its presence in the global space ecosystem, the insights from this conference become even more relevant. They underline the importance of collaboration, innovation, and a willingness to think beyond conventional limits.

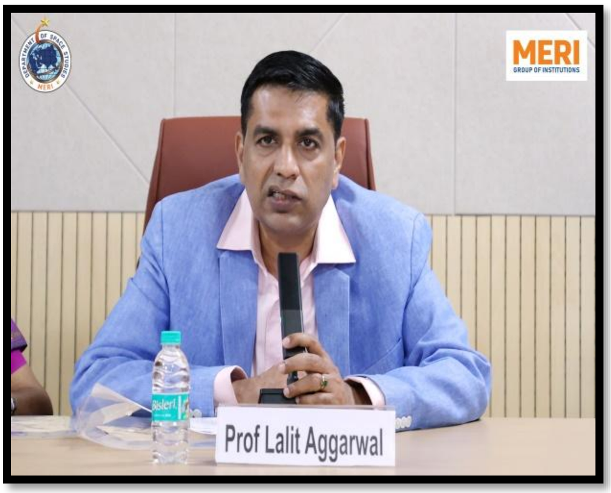
This report aims to capture those ideas, discussions, and perspectives- bringing together not just what was said, but what it means for the future of science, healthcare, and humanity itself.

TECHNICAL SESSIONS

The opening technical session set the foundation by exploring the intersection of space technology, human health, and pharmaceutical research, highlighting both opportunities and critical challenges for long-duration space missions.

Prof. (Dr.) Lalit Aggarwal, Vice President, MERI Group of Institutions.

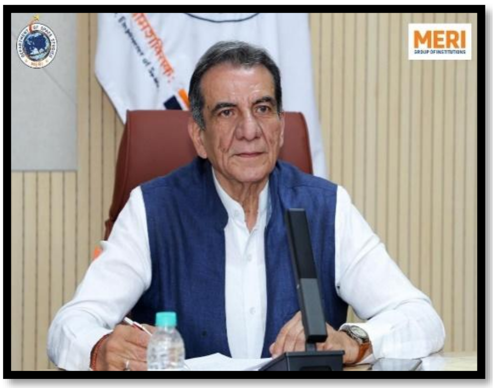
Prof. Lalit Aggarwal emphasized on the convergence of space technology and pharmaceutical research as a transformative pathway for India's growth, highlighting how integrating these domains can accelerate innovation in drug discovery and healthcare solutions. He stressed the need for India to move beyond its reliance on generic manufacturing toward high-value research and innovation, while underlining the crucial role of academic institutions like MERI in fostering interdisciplinary collaboration between space science, healthcare, and industry. He further advocated for building a strong, integrated ecosystem to support space-based research, positioning the space-pharma sector as a strategic driver for India's global leadership.



Release of Report FarmTech 2026

A report on New Developments & Space: 'Based Farming Techniques in India' a conference conducted on 17th February 2026 was released by the dignitaries from MERI group of Institution and SIA, India.

Mr. Pawan Kapur, Board member SIA, India



Mr. Pawan Kapur, appreciated the release of the FarmTech 2026 report. He highlighted the significant potential of space in advancing pharmaceutical research and appreciated the strong synergy between MERI and SIA in driving such initiatives. He noted that this marks one of the early explorations of Indian pharma research in the space domain, but also raised concerns that if employment opportunities in the space sector remain limited, the high costs involved may outweigh the benefits. Referring to global developments, including China's Tiangong space station, he suggested that any nation with space capabilities can leverage these advancements, while underscoring India's vision of establishing the Bharat Antariksh Station as a key step toward future growth.

Lt Gen PJS Pannu, PVSM, AVSM, VSM, PhD (Retd)
Advisor, SIA and Chief Mentor, Dept of Space Studies (DSS-MERI)

Delivering the thematic address, Lt Gen Pannu presented a forward-looking vision for space-based pharmaceutical research. He brought out the following:

(a) Bharat Antariksh Station as a future hub for advanced research.

(b) Fully automated "Dark Labs" in orbit, designed for Drug development in microgravity.

(c) Microgravity enables high-precision drug crystallization.

(d) Space-based labs could significantly accelerate drug discovery time lines.

He also compared India's ambitions with global developments, emphasizing the need for long-term strategic planning and international competitiveness.

Theme	Key Points	Strategic Impact
Orbital Infrastructure	Bharat Antariksh Station	Long-term R&D hub
Innovation	Dark Labs (automated labs)	Faster experimentation
Global Positioning	Competing with global players	Strategic leadership

Key Note Address - Padma Shri, Dr. Mrs. Padma Bandopadhyay PVSM, AVSM, VSM, PHS (Retd)

The Evolution of Space Medicine

Dr. Bandopadhyay brought out the important landmarks in the evolution of space medicine, strategic roadmap of Gaganyaan and physiological hazards of space flight. She explained in detail the neurosensory challenges and radiation risk management for space crew.

Key Takeaways:

(a) Evolution of Space Medicine: Transition from short-term survival (1960s) to comprehensive, long-duration healthcare systems for space missions.

(b) Microgravity Countermeasures: Addressing fluid shifts, cardiovascular deconditioning, bone and muscle loss, motion sickness, and behavioral health challenges.

(c) India's Advancements: Strong focus on programs like Gaganyaan and future Bharatiya Antariksha Station.

(d) Astronaut Training & Operations: Extensive selection protocols and adaptation of clinical procedures such as CPR in microgravity.

(e) Space Pharmacy Innovations: Research on drug stability under radiation and vibration, 3D-printed medicines, and extended shelf-life testing.

(f) Earth Applications: Telemedicine, GNSS-based epidemiology, portable diagnostics, and tissue-chip research benefiting terrestrial healthcare.

Focus Area	Insights	Impact
Accessibility	Research should be simplified	Wider adoption
Policy Integration	Space pharma in national health policy	System-level change
Collaboration	Interdisciplinary approach	Faster innovation

Challenges:

(a) Physiological Risks: Bone density loss, muscle atrophy, cardio vascular issues, and neurosensory disturbances.

(b) Radiation Exposure: Increased long-term health risks requiring advanced protective strategies.

(c) Drug Stability Issues: Medicines degrade under space conditions like radiation, microgravity, and vibration.

(d) Operational Constraints: Limited medical infrastructure and complexity of performing procedures in space.

(e) Long-Duration Missions: Need for sustainable healthcare systems for Moon and Mars missions.

Presentation 1: Air Vice Marshal Dr. Anupam Agarwal, VSM (Retd) MBBS, MD, Dip Av Med, FISAM

Pharmaceutical Challenges in Space Missions

The session brought out the key challenges in going from earth to space and it emerged explicitly that there is a requirement of a complete paradigm shift in thinking and approach. The speaker mentioned that fluid dynamics collapse when liquids and gases no longer separate in space settings and issues like this need to be fixed before launching space missions.

Key Takeaways:

(a) **Drug Degradation in Space:** Radiation exposure, elevated CO_2 levels, and microgravity accelerate the degradation of medicines, reducing their effectiveness.

(b) **Need for Space-Compatible Drugs:** Medicines must be redesigned to be highly stable, compact, and multifunctional to suit space conditions.

(c) **Orbital Manufacturing:** Introduction of automated “Dark Labs” in orbit can enable on-demand drug production.

(d) **Self-Sustaining Systems:** Future missions require independent pharmaceutical systems rather than reliance on Earth-based supply chains.

(e) **Storage and Packaging Innovations:** Advanced packaging is required to maintain drug stability under extreme conditions.

Category	Key Observations	Impact
Drug Stability	Accelerated degradation in radiation	Reduced effectiveness
Storage	Need for compact packaging	Payload constraints
Manufacturing	Orbital labs required	Mission sustainability
Regulation	Lack of OGMP	Delayed progress
Infrastructure	Limited on-board systems	Operational challenges

Challenges:

(a) **Lack of Regulatory Frameworks:** No established standards exist for manufacturing and validating drugs in space.

(b) **Quality Control Issues:** Ensuring consistent drug quality in microgravity is complex.

(c) **Limited Research Data:** Insufficient long-term studies on drug stability in space environments.

(d) **Operational Constraints:** Limited space, resources, and infrastructure onboard spacecraft.

Challenges	Explanation
Regulatory Gap	No space pharma standards
Infrastructure	Limited onboard systems
Data Limitations	Lack of long-term studies

Dr. Agarwal concluded that the future of space exploration depends on developing robust and self-reliant pharmaceutical ecosystems. Establishing regulatory frameworks, investing in research, and leveraging orbital manufacturing technologies will be essential for ensuring human survival in deep-space missions.

Presentation 2: Mr. Tejpaul Bhatia, Ex-CEO, Axiom Space

Space-Enabled Pharmaceutical Business Innovation

Bringing a global industry perspective, Mr. Tejpaul Bhatia highlighted the rapid bringing together of global industry perspective; he highlighted the rapid commercialization of space-based pharmaceutical research. Drawing from his experience across leading organizations, he emphasized the growing role of private players in advancing microgravity research and pointed to successful experiments in drug crystallization conducted in orbit. His insights reflected a shift from exploratory research to real-world industrial application in the space pharmaceutical sector.

Key Takeaways:

(a) Commercialization of Space Pharma: Space-based pharmaceutical research is rapidly transitioning from experimental stages to commercially viable applications, attracting strong industry interest.

(b) Role of Private Players: Increasing participation of private companies is accelerating innovation and investment in microgravity research.

(c) Drug Crystallization in Microgravity: Successful in-orbit experiments demonstrate that microgravity enables the formation of highly pure and effective drug structures.

(d) Improved Drug Performance: Enhanced molecular structure leads to better drug efficacy and stability compared to Earth-based formulations.

(e) Faster Development Cycles: Microgravity conditions can streamline drug development timelines, reducing time-to-market.

(f) Global Leadership Opportunity: Early adoption and investment in space pharma will be critical in determining leadership at a global level.

Category	Key Observations	Impact
Commercialization	Shift from experimental to market-ready solutions	Emergence of new pharma markets
Private Sector Role	Increased involvement of private players	Faster innovation and funding inflow
Drug Development	Microgravity enables superior crystallization	Improved drug quality and effectiveness
R&D Efficiency	Accelerated development cycles	Reduced time-to-market
Global Competition	Early movers gain advantage	Strategic leadership in space pharma

Challenges:

(a) Regulatory Uncertainty: Lack of clear global regulatory frameworks for space pharmaceuticals may slow adoption.

(b) Early-Stage Industry Risks: Despite progress, the sector is still evolving with uncertainties in scalability and long-term viability.

(c) High Investment Requirements: Space-based research and manufacturing require significant capital and infrastructure.

(d) Access and Infrastructure Limitations: Limited access to space platforms and dependence on specialized missions restrict widespread experimentation.

Challenges	Explanation
Industry Maturity	Transition phase from experimental to commercial
Investment Barriers	High cost of space missions and R&D
Regulatory Gap	Absence of standardized global policies
Infrastructure Constraints	Limited access to orbital research facilities

Mr. Bhatia concluded by harping upon the fact that space based pharmaceutical and healthcare research is the buzz word in industry today and the people who initiate their work in this domain will definitely have a first mover advantage.

Presentation 3: Dr Neeta Kumar, MBBS, MD, Oncology, Cancer and Public Health Specialist

Health Aspects in Space and High Altitude - Current Scenario and Researchable Areas

Dr. Neeta Kumar initiated her session by pointing out the fact that India's first astronaut happens to also be the first Antariksh Yogi as he practiced yoga to overcome micro gravity challenges. She highlighted that the main role of space medicine is to prevent, diagnose and treat diseases likely to affect the space crew. Her session focused on health challenges and possible research avenues of space medicine.

Key Takeaways:

(a) Physiological Challenges: Muscle atrophy, bone density loss, and cardiovascular changes are major concerns.

(b) Psychological Impact: Isolation, stress, and sleep disturbances affect astronaut performance.

(c) High-Altitude Analogy: Space conditions are comparable to hypoxic and extreme environments on Earth.

(d) Telemedicine and AI: Remote diagnostics and AI-based systems enable continuous monitoring.

(e) Wearable Technologies: Real-time health tracking improves preventive care.

(f) **Traditional Medicine Integration:** Use of adapt to gens and herbal formulations enhances resilience.

(g) **Breathing Techniques:** Practices like pranayama improve oxygen utilization and mental well-being.

Category	Key Observations	Impact
Physiology	Muscle & bone loss	Health deterioration
Mental Health	Stress & isolation	Performance decline
Technology	AI & wearables	Preventive care
Medicine	Traditional integration	Holistic treatment

Challenges:

(a) **Limited Validation:** Traditional medicine lacks extensive testing in microgravity.

(b) **Storage Issues:** Herbal formulations may face stability challenges.

(c) **Training Requirements:** Astronauts must be trained for self-administered healthcare.

Challenges	Explanation
Validation	Limited microgravity testing
Storage	Herbal instability
Training	Astronaut readiness

Dr. Neeta concluded her session by highlighting the need and importance of strong interaction between medical academia and pharmaceutical industry to foster the space-based research initiatives.

Presentation 4: Dr. Anjan Sen

Microgravity and Drug Discovery

Dr. Sen brought out the importance of drug research in microgravity conditions and what implications such studies may have on drug discovery and potential improvement in speed and cost effectiveness of drug research and commercialization. He pointed out the India needs to gear up in this field by collaborating with academia and industry to support such research missions.

Key Takeaways:

(a) **High-Quality Crystals:** Enables formation of pure protein crystals for better drug design.

(b) **Elimination of Convection:** Microgravity removes sedimentation and convection effects.

(c) **Improved Drug Targeting:** Enhances molecular precision.

(d) **Accelerated Research:** Speeds up drug discovery timelines.

Category	Key Observations	Impact
Crystallization	High precision crystals	Better drug design
Research Speed	Faster discovery	Innovation boost
Cost	High experimentation cost	Limited access

Challenges:

(a) High Experimentation Costs: Conducting research in space is expensive.

(b) Limited Access: Restricted availability of microgravity environments.

(c) Infrastructure Needs: Requires specialized facilities and expertise.

Dr. Sen concluded that microgravity offers a transformative platform for pharmaceutical innovation, enabling breakthroughs that are not possible under Earth conditions.

Presentation 5: Air Commodore (Dr) Sandeep Arora, (Retd)
Senior Consultant Dermatologist

Aerospace Dermatology & It's Need for a Dedicated Pharmacopoeia

Focusing on space dermatology, Air Cmde Sandeep Arora highlighted the significant impact of microgravity on skin health. Drawing from observations in astronaut missions, he emphasized how space conditions alter human physiology, particularly affecting skin structure and function. His insights underscored the emerging need for specialized dermatological care and targeted pharmaceutical solutions for space environments.

Key Takeaways:

(a) Impact of Microgravity on Skin: Microgravity significantly affects skin health, leading to physiological changes in astronauts.

(b) Increase in Skin Rashes: Studies indicate up to a 25x increase in skin rashes in space conditions.

(c) Skin Thinning: Nearly 20% reduction in skin thickness has been observed in astronauts during missions.

(d) Altered Skin Function: Microgravity impacts skin regeneration and immune response, increasing vulnerability to dermatological issues.

(e) Need for Specialized Treatments: Traditional dermatological solutions may not be effective in space, requiring tailored treatments.

(f) Emerging Space Skincare Segment: There is growing scope for development of space-specific skincare and pharmaceutical products.

Category	Key Observations	Impact
Skin Health	Increased rashes in microgravity	Higher dermatological risks
Skin Structure	~20% thinning of skin	Reduced protective barrier
Physiology	Altered regeneration and immunity	Increased susceptibility to conditions
Treatment Needs	Lack of space-specific solutions	Demand for specialized care
Product Innovation	Scope for new skincare solutions	Emerging market opportunities

Challenges:

(a) Limited Research Data: There is a lack of extensive long-term studies on skin health in microgravity environments.

(b) Absence of Specialized Products: Existing skincare and dermatological treatments are not designed for space conditions.

(c) Physiological Complexity: Understanding skin behavior in microgravity remains scientifically challenging.

(d) Operational Constraints: Limited medical infrastructure onboard spacecraft restricts advanced dermatological care.

Challenges	Explanation
Data Limitations	Insufficient long-term dermatology studies in space
Product Gaps	Lack of space-compatible skincare solutions
Scientific Complexity	Limited understanding of microgravity effects on skin
Infrastructure Constraints	Restricted onboard medical facilities

Dr. Arora concluded his session by underlining the role of dermatology studies both for astronauts as well as the possible implications of the research studies conducted on breakthrough molecules in space analog settings and their possible commercial implications on dermatology products, and their utility on earth.

Presentation 6: Sree Supranayi, Co-Founder and CEO AnduraX
Space as the Next Pharmaceutical Laboratory

The role and importance of infrastructure, access and the future of drug discovery was emphasised. The speaker identified four major areas of space based pharmaceutical research; Stem cell research, Oncology, 3D bio printing and protein crystallization. She explained the role of reusable space planes for conducting pharmaceutical research experiments in microgravity environment.

Key Takeaways:

(a) Reusable Space planes: ARES and SPARC enable efficient transportation.

(b) Soft Re-entry: Minimizes stress on biological samples.

(c) Faster Recovery: Reduces return time from 16 hours to 2 hours.

(d) Down mass Solution: Efficiently returns materials from space.

Category	Key Observations	Impact
Logistics	Faster return systems	Research efficiency
Technology	Reusable systems	Cost reduction
Infrastructure	Limited scale	Adoption barriers

Challenges:

(a) Engineering Complexity: Advanced design requirements.

(b) High Costs: Development and deployment are expensive.

(c) Scalability Issues: Limited operational infrastructure.

Challenges	Explanation
Engineering	Complex systems
Cost	High development cost
Scalability	Limited infrastructure

She concluded that efficient logistics systems are essential for scaling space-based research and ensuring timely transportation of critical materials.

Presentation 7: Dr. Parijat Pandey, In-Charge, Department of Pharmaceutical Sciences, Gurugram University

Nanotechnology and Advanced Drug Delivery Systems

As a pharmacist, Dr. Pandey pointed out the key challenges that include predictable as well unpredictable environments in space and their impact on the health of astronauts as well as their effect on the ongoing pharmaceutical research experiments. His session focused primarily on pharma stability issues such as microgravity, radiation, loss of drug potency and changes in pharmacodynamics and pharmacokinetics of drugs.

Key Takeaways:

(a) Nano-Encapsulation: Enhances drug stability and controlled release.

(b) Targeted Delivery: Improves effectiveness and reduces side effects.

(c) 3D Bioprinting: Enables tissue engineering in microgravity.

(d) Regenerative Medicine: Supports development of advanced therapies.

Category	Key Observations	Impact
Crystallization	High precision crystals	Better drug design
Research Speed	Faster discovery	Innovation boost
Cost	High experimentation cost	Limited access

Challenges:

(a) High Costs: Nano technology research is resource-intensive.
(b) Scalability Issues: Difficult to implement at large scale.
(c) Regulatory Gaps: Lack of clear frame works for advanced therapies.

Challenges	Explanation
Scalability	Hard to mass produce
Cost	High investment
Regulation	No clear policies

Dr. Pandey concluded that nanotechnology combined with space research will drive future advancements in precision medicine and healthcare innovation.

DELIBERATIONS

The deliberations served as a critical platform for aligning diverse stakeholder perspectives, bringing together representatives from space agencies, health care institutions, pharmaceutical companies, research organizations, and policy bodies. Unlike the technical sessions, which focused on innovation and scientific advancements, this segment emphasized practical implementation, scalability, and real-world constraints.

A dominant concern raised across all stakeholders was the high cost of conducting pharmaceutical research in space. Launch expenses, payload limitations, and restricted access to microgravity environments significantly increase the cost of experimentation. Industry representatives highlighted that without financial incentives, subsidies, or shared infrastructure models, private sector participation would remain limited. This reinforces the need for government-backed funding mechanisms and risk-sharing frameworks.

Another key issue discussed was the absence of a clear regulatory framework for space-based pharmaceutical production. Experts pointed out that while terrestrial drug manufacturing follows stringent guidelines such as Good Manufacturing Practice (GMP), there is currently no equivalent system for space environments. The proposed concept of Orbital Good Manufacturing Practice (OGMP) was widely supported, with stakeholders emphasizing that regulatory clarity is essential for ensuring safety, quality assurance, and global acceptance of space-developed pharmaceuticals.

The discussion also highlighted the importance of public–private collaboration. Space agencies like ISRO possess the infrastructure and technical expertise, while pharmaceutical companies bring domain knowledge in drug development and commercialization. However, the lack of structured collaboration platforms leads to fragmented efforts. Participants recommended establishing integrated innovation ecosystems where academia, government, and industry can co-develop solutions, share data, and accelerate research timelines.

From a healthcare perspective, experts stressed that innovations developed for space must not remain confined to astronaut applications. Instead, there is a strong need to translate space-based research into terrestrial healthcare benefits, such as improved drug formulations, advanced therapies, and cost-effective treatment solutions. This alignment ensures that investments in space pharma deliver broader societal value.

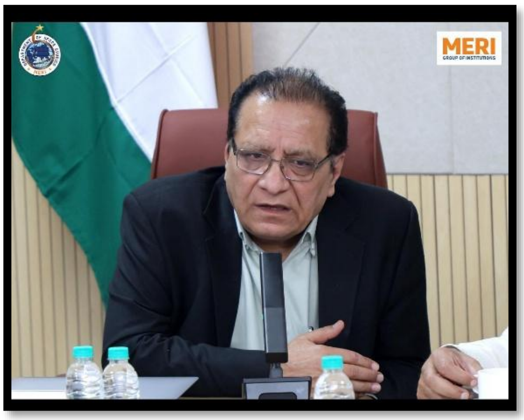
Another critical theme was scalability and commercialization. While experimental success in space is promising, stakeholders questioned whether these innovations can be produced at scale and integrated into existing pharmaceutical supply chains. Challenges such as manufacturing costs, technology transfer, and market accessibility were identified as major barriers.

Additionally, participants discussed the need for capacity building and interdisciplinary expertise. The emerging field of space pharma requires professionals skilled in both life sciences and space technology. Currently, such expertise is limited, indicating the need for specialized training programs and academic curricula.

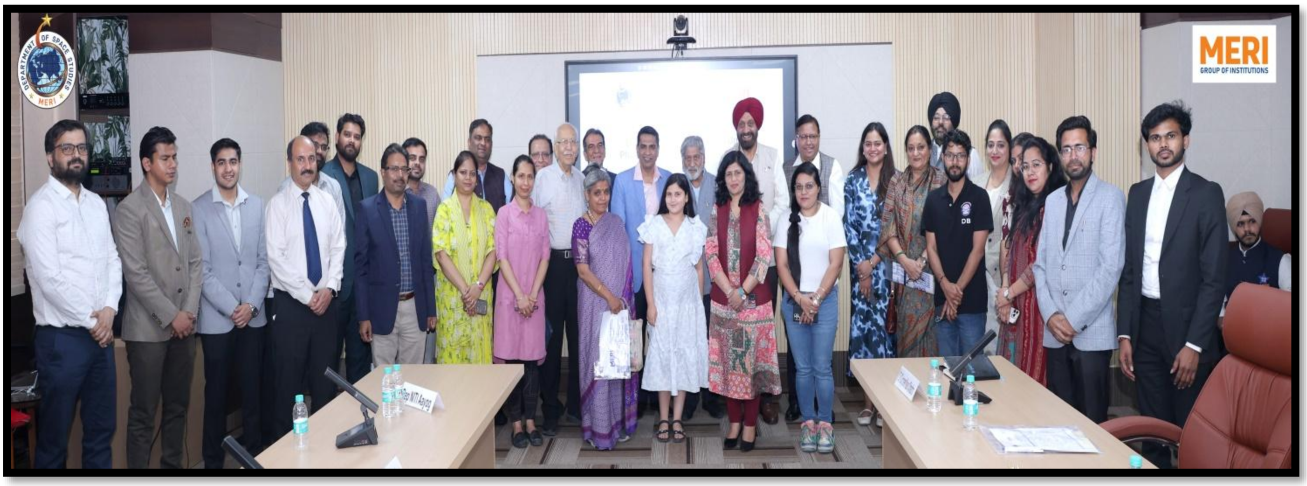
Finally, the discussion emphasized international collaboration as a strategic necessity. Given the high costs and technical complexity of space research, partnerships with global space agencies and pharmaceutical firms can help India accelerate progress, share knowledge, and establish itself as a leader in this domain.

Theme	Discussion	Outcome
Cost	High research & launch costs	Need subsidies
Regulation	No OGMP framework	Policy development required
Collaboration	Fragmented ecosystem	PPP model needed
Scalability	Hard to commercialize	More R&D investment
Skill Gap	Lack of expertise	Training programs needed

Closing Address by Mr. Ravi Ailawadhi, Board member, SIA



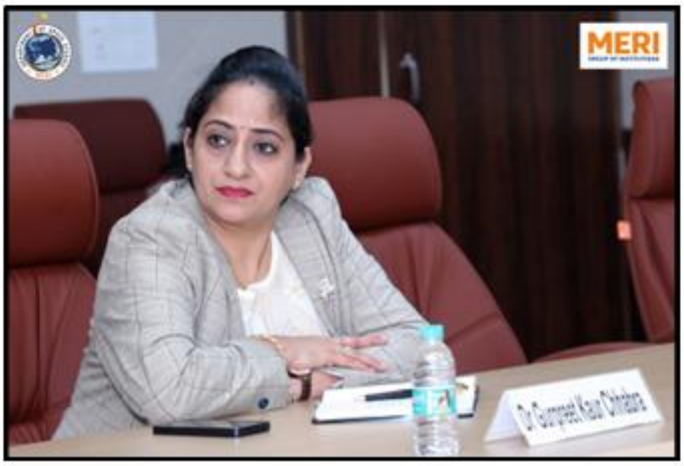
In his closing remarks Mr. Ravi Ailawadhi, Board member, SIA, India, extended his heartfelt gratitude to all distinguished speakers, guests, and participants for contributing to the success of the conference. He highlighted key outcomes of the closing session, including the confirmation of the India Space Congress 2026 track, the announcement of the ISRO-AIIMS collaboration, and the recognition of MERI Space Club's achievements. He noted that these milestones reflect the collective efforts and shared vision of all stakeholders in advancing space and pharmaceutical research in India, and expressed appreciation for the continued support and engagement in the community.



SUMMARY OF RECOMMENDATIONS

Category	Key Recommendations	Responsible Entities	Timeline
Regulatory Framework	Establish Orbital Good Manufacturing Practice (OGMP) standards for drug production in space; develop validation protocols for microgravity - based pharmaceuticals; create fast-track. Approval pathways for space-derived drugs	CDSCO, ISRO, ICMR, Ministry of Health	Short Term (1–2 years)
Space Pharma Infrastructure	Develop orbital laboratories ("Dark Labs") for autonomous drug research; invest in Bharat Antariksh Station as a pharma research hub; create dedicated payload capacity for pharma experiments	ISRO, IN-SPACe, Private Space Firms	Medium Term (3–5 years)
Research & Innovation	Fund microgravity-based drug discovery programs; promote interdisciplinary R&D combining pharma, biotech, and space science; incentivize universities to establish space health research centers	DST, DBT, Universities, Research Institutes	Ongoing
Public–Private Partnerships (PPP)	Strengthen collaboration between ISRO, AIIMS, biotech startups, and pharma companies; create joint innovation platforms; reduce research wait times through shared infrastructure	ISRO, AIIMS, Private Pharma Firms	Short to Medium Term
Healthcare Systemsfor Space	Develop integrated astronaut healthcare systems using AI, wearable devices, and telemedicine; standardize protocols for long-duration missions	ISRO, ICMR, DRDO, Health Tech Firms	Medium Term (2–4 years)
Drug Stability & Packaging	Invest in radiation-resistant packaging and nano-encapsulation technologies; develop compact, multi-functional drug formulations for space missions	Pharma Companies, DRDO, Research Labs	Short to Medium Term
Digital & AI Integration	Implement digital twin systems for real-time monitoring of astronaut health; deploy AI for predicting Drug stability and physiological changes	ISRO, Tech Companies, Startups	Short Term (1–3 years)
Reusable Space Logistics	Promote development of reusable space planes for faster sample return; reduce down mass time for pharmaceutical experiments	ISRO, Private Aerospace Firms	Medium Term (3–5 years)
Capacity Building & Skill Development	Introduce training programs in space medicine, astro-pharmacy, and bioengineering; develop specialized academic curriculum	Universities, ISRO, Medical Institutes	Ongoing

International Collaboration	Partner with global space agencies and pharma companies for joint missions and knowledge exchange; participate in global Regulatory standard-setting	ISRO, Ministry of External Affairs	Long Term (5+ years)
Funding & Incentives	Provide grants, tax incentives, and venture funding support for startups in space pharma; create dedicated innovation funds	Government, NITI Aayog, Venture Funds	Short Term
Ethics & Safety Governance	Develop ethical guidelines for human testing in space; ensure safety standards for astronauts and experimental subjects	ICMR, CDSCO, International Bodies	Medium Term



DEPARTMENT OF SPACE STUDIES MERI

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Empowerer of the Earth, Empowerer of Space.

SIAINDIA

An association for space industry

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GROUP OF INSTITUTIONS

GLOSSARY

1. **Microgravity**: A condition in space where gravitational forces are extremely weak, allowing biological and chemical processes to behave differently compared to Earth.
2. **Protein Crystallization:** A process used in drug discovery where proteins form structured crystals; in microgravity, these crystals are more uniform, enabling precise drug design.
3. **Orbital Good Manufacturing Practice (OGMP):** A proposed regulatory framework for ensuring quality, safety, and consistency in pharmaceutical production conducted in space environments.
4. **Bioprinting (3D Bioprinting):** A technology that uses 3D printing techniques to create biological tissues and potentially organs, often enhanced in microgravity due to the absence of structural constraints.
5. **Nano-encapsulation:** A drug delivery technique where medicines are enclosed within nano scale carriers to improve stability, targeting, and controlled release.
6. **Digital Twin:** A virtual simulation model of a physical system (such as the human body) used to monitor, predict, and optimize health conditions in real time.
7. **Pharmacokinetics:** The study of how drugs are absorbed, distributed, metabolized, and eliminated in the body, which changes significantly in space conditions.
8. **Down Mass:** The process of transporting materials, experimental samples, or manufactured products from space back to Earth.
9. **Microgravity Research:** Scientific experimentation conducted in low-gravity environments to study changes in physical, chemical, and biological processes.
10. **Monoclonal Antibodies:** Laboratory-produced molecules designed to target specific antigens, widely used in cancer therapy and immune-related treatments.
11. **Scaffold-free Bioprinting:** A method of tissue engineering where biological structures are printed without artificial support frameworks, made possible by microgravity conditions.
12. **Radiation-induced Degradation:** The breakdown of pharmaceutical compounds due to exposure to cosmic radiation, leading to reduced effectiveness or toxicity.
13. **Telemedicine:** The use of digital communication technologies to provide remote medical consultation, diagnosis, and treatment.
14. **Wearable Biosensors:** Devices worn on the body that continuously monitor physiological parameters such as heart rate, oxygen levels, and stress indicators.
15. **Space Logistics Systems:** Infrastructure and technologies used for transporting materials, equipment, and research payloads to and from space.
16. **Reusable Space planes:** Advanced spacecraft designed for multiple missions, reducing the cost and time associated with space travel and cargo return.
17. **Dark Labs (Orbital Labs):** Fully automated laboratories in space designed to conduct pharmaceutical and biological experiments with minimal human intervention.

Annexure I

ABOUT THE ORGANISERS

MERI Group of Institutions

MERI Group of Institutions transforms students from foundational learners (Pre) to industry-ready professionals (Pro) through its cutting-edge curriculum, expert mentorship, and holistic development approach. Establishedin1987, MERI has been at the leading edge of nurturing young minds, fostering innovation, and developing future leaders across various disciplines. MERI bridges the gap between theory and practice, offering experiential learning, global collaborations, and advanced skill- building programs. The institute's state-of-the-art infrastructure, industry exposure, and robust placement support ensure students are equipped to excel in the modern professional landscape. At MERI, every learner is empowered to lead, innovate, and succeed.

MERI Group of Institutions is a premier academic institution providing quality education in India for the past 37 years in the States of New Delhi and Haryana. MERI- Group is an ISO 9001:2015 certified & NAAC accredited institution. It has established itself as a Centre of Excellence in education, with focus on providing quality education in the fields of Engineering, Management, Law, Journalism, Information Technology, Teacher's Training and School Education. Presently, five academic institutions are being operated by the Group in New Delhi and NCR

Presently, MERI-Group has 30+ Global partnerships with reputed Universities and Educational Institutions from Thailand, China, South Korea, France, Germany, Bulgaria and Canada for students & faculty exchange, research, and related academic activities. MERI Group of Institutions is striving to help youth to develop their skills and values by not just letting them go through life but grow through life.

MERI Department of Space Studies

The Department of Space Studies (DSS) at the Management Education & Research Institute (MERI), New Delhi, is an autonomous centre of excellence dedicated to advancing research in cosmology and promoting scientific awareness at the grassroots level. Launched with strong academic enthusiasm, the department reflects MERI's commitment to futuristic and interdisciplinary education, integrating space science with technology, management, policy, and innovation. DSS focuses on cutting-edge research in cosmological topics, while also popularizing science to nurture a scientific temper among the wider population. Its faculty maintain active collaborations with national and international research networks, ensuring global exposure and academic rigor.

Space Industries Association – India (SIA – India)

The Space Industry Association (SIA-India) is a not-for-profit organization representing the interests of India's space and satellite communication industry. It serves as a platform for thought leadership on policy, regulatory, and spectrum-related matters, working closely with government agencies, regulatory bodies, and international stakeholders to foster a conducive business and regulatory environment. Its membership spans satellite operators, manufacturers, suppliers, startups, academic institutions, and law firms, reflecting the diverse ecosystem of the space sector. SIA-India is dedicated to advancing industry growth, catalyzing innovation, and strengthening India's position in the global space economy. Recently, in collaboration with CERT-In under the Ministry of Electronics and Information Technology, SIA-India released comprehensive guidelines on space cyber security, underscoring its commitment to safeguarding satellite communication systems that are vital for national security, disaster response, navigation, broadcasting, and economic resilience.

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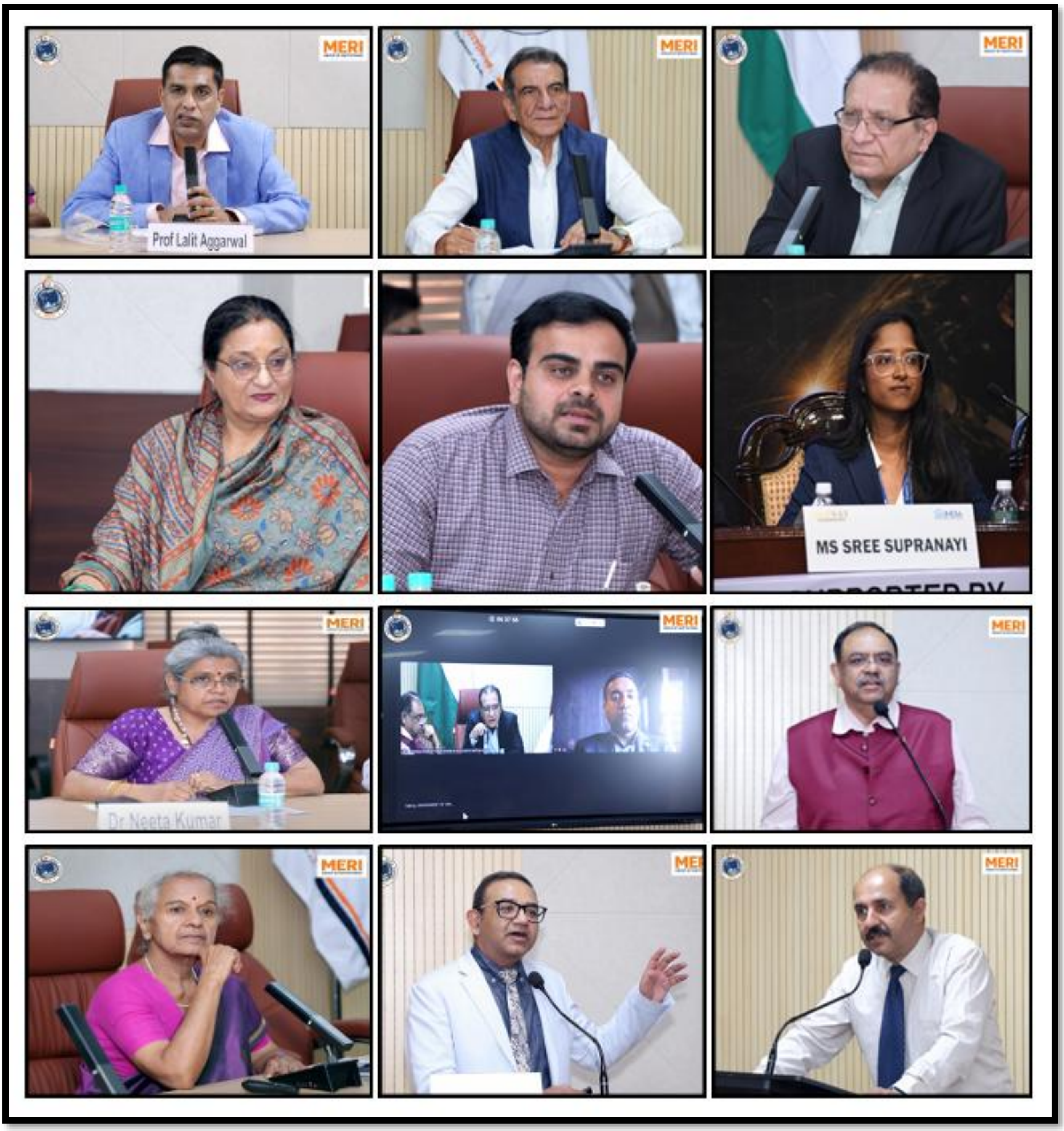
Annexure III

PHOTO GALLERY

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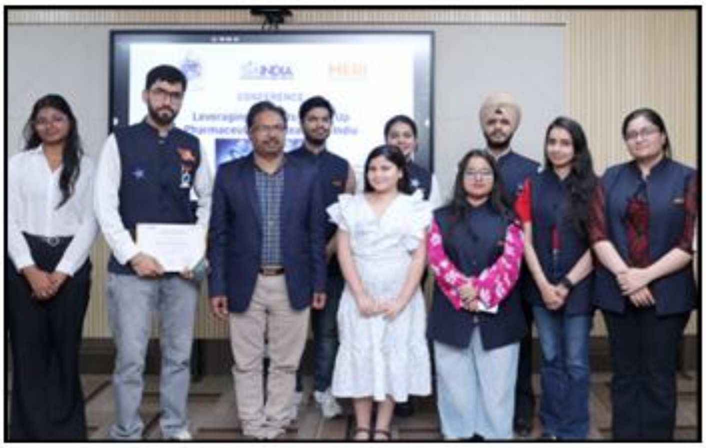

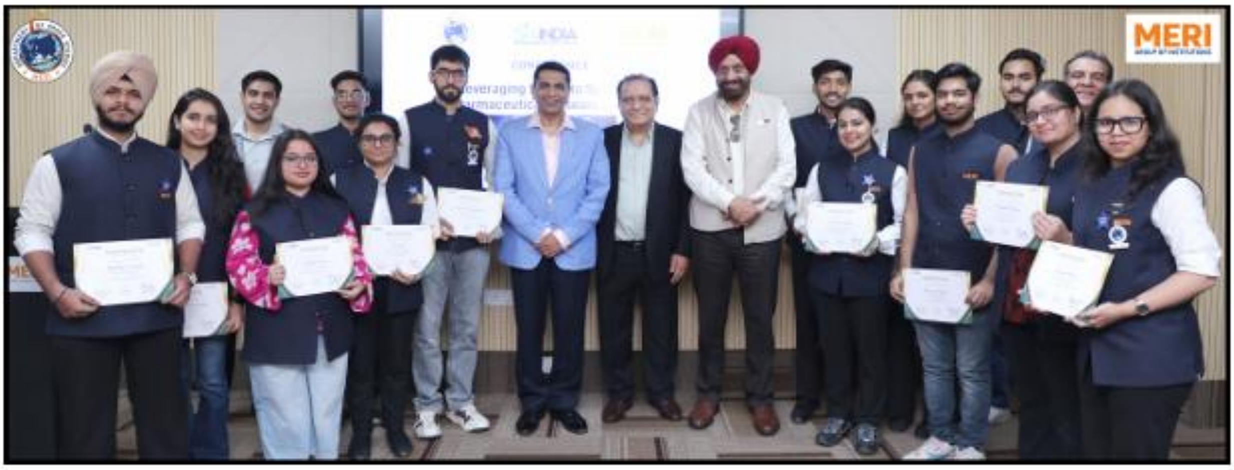
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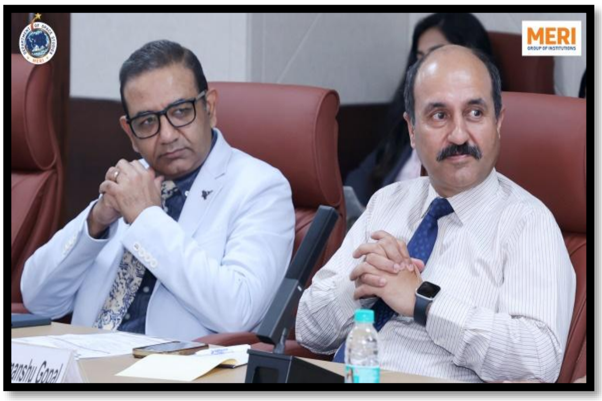
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