Driving change: Digital innovation and the future of drug discovery in India

Dr Trupti Kad-Shinde, Senior member, Medical Research and content team, ImmersiveVision Technology and **Dr Debashree Das,** pharmacologist and medical writer, express that pharmaceutical education must undergo a fundamental transformation to realise India's true potential in drug discovery

India's pharmaceutical prowess is indisputable. Home to nearly 10,000 manufacturing units, 3,000 companies (1), and more than 650 USFDA-approved facilities, the country plays a central role in the global supply of generics. This manufacturing strength is further complemented by a robust academic ecosystem with over 4,000 pharmacy institutions that generate a steady pipeline of graduates, patents, and publications.

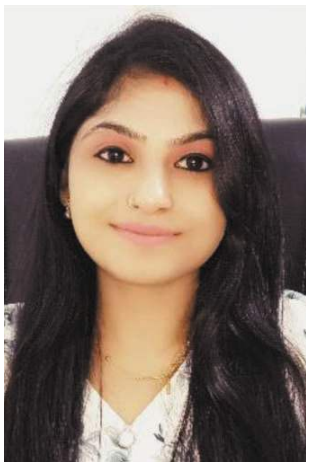
The last mile challenge

Despite this impressive output, India still ranks 39th on the Global Innovation Index (2), underscoring that while the country leads in generics, progress in new drug discovery is significantly slow (3). A major reason for this challenge is that pharma struggles in crossing the last but critical mile in the drug discovery—the preclinical to clinical leap (4).

At the heart of the problem is a research culture that often treats publications and patents as endpoints, not beginnings. Promising hypotheses are filed away in journals or locked behind IPRs, rarely progressing toward clinical application (5). It's akin to drafting blueprints for a remarkable house but never actually building it.

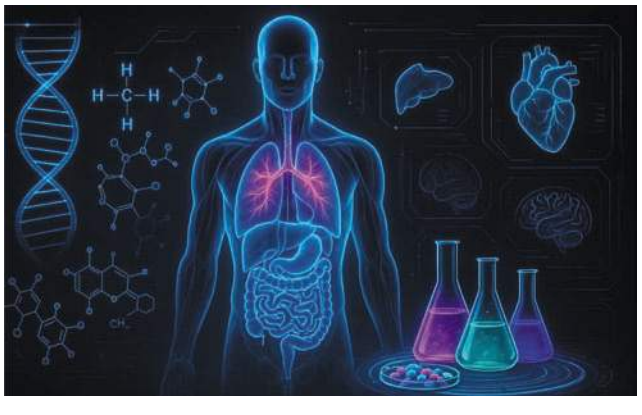
Even academia is more production-oriented. It places way more emphasis on hands-on training for pharmaceutics, medicinal chemistry, and pharmaceutical analysis while sidelining practicals in foundational sciences like human anatomy, physiology, pathophysiology, and clinical pharmacology. The outcome is a workforce well-prepared for manufacturing but underequipped for discovery and innovation.

Dr Trupti Kad-Shinde



Dr Debashree Das

Consequently, industry is more inclined to recruit from rather than collaborate with academia—a reality highlighted by India's 86th rank in global academia–industry R&D collaboration, as reported by the World Intellectual Property Organization (6).



Thus, to realise its true potential, India must strive to forge deeper, more strategic partnerships between academia and industry. Industry must endeavour to invest not only in infrastructure but also in mentorship, facilities, and translational platforms (7). While academia needs to strive towards cultivating a translational mindset in future researchers, one that doesn't stop at "what does this molecule do?" but extends to "how does it behave in a human system, and how will it improve patient outcomes?"

The vital role of human biology

Drug discovery is not just a chemical or pharmaceutical challenge. It's a biological one with human biology at its epicentre. According to the US Food and Drug Administration, the path of drug discovery and development follows four key stages: target identification and validation, lead discovery and optimisation, preclinical studies, and clinical trials (8).

And across every step, one element remains consistently central—human biology. Let's take a look at how.

Identifying a molecular target involves discerning a disease-relevant druggable biomolecule. It demands a clear understanding of its anatomical location, along with its physiological role and how its function changes in disease. Optimising lead compounds, in turn, calls for deep insight into how even subtle chemical

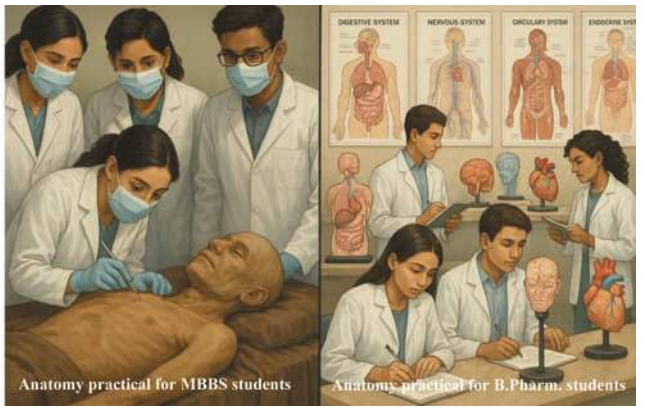
The last mile challenge: Preclinical to clinical

Industry-academia collaboration

modifications of the candidate can shift its activity within the complex biological systems (9).

Preclinical testing in animals must also be interpreted through a human lens to identify cases of false positives, false negatives, and other blind spots that may distort bench-to-bedside translation of the candidate (10). Thus, before a molecule can be developed into a successful medicine, it must not only demonstrate favourable physical and chemical properties and promising outcomes in animal models but also have its safety and efficacy rigorously vetted in human systems. This is where the complexities of human biology come sharply into focus (11).

Understanding human anatomy is crucial for identifying the sites where drugs are absorbed, metabolised, and exert their pharmacological effects. Physiology not only helps to understand the normal functioning of the human body, but also helps in understanding the processes by which drugs are bio-transformed, distributed throughout the body, and excreted. Pathology highlights how diseases alter these physiological processes and how a drug candidate can interact with the target biomolecules to mitigate pathological consequences (12). This integrated approach not only facilitates informed target identification and dosing strategies but also equips future researchers to recognise the micro-anatomical, physiological, and pathophysiological differences between animal models and human systems. By acknowledging these nuances, they can predict whether a candidate successful in the preclinical phase will or will not be of equal value in clinical trials, potentially saving billions of dollars in failed attempts (13).

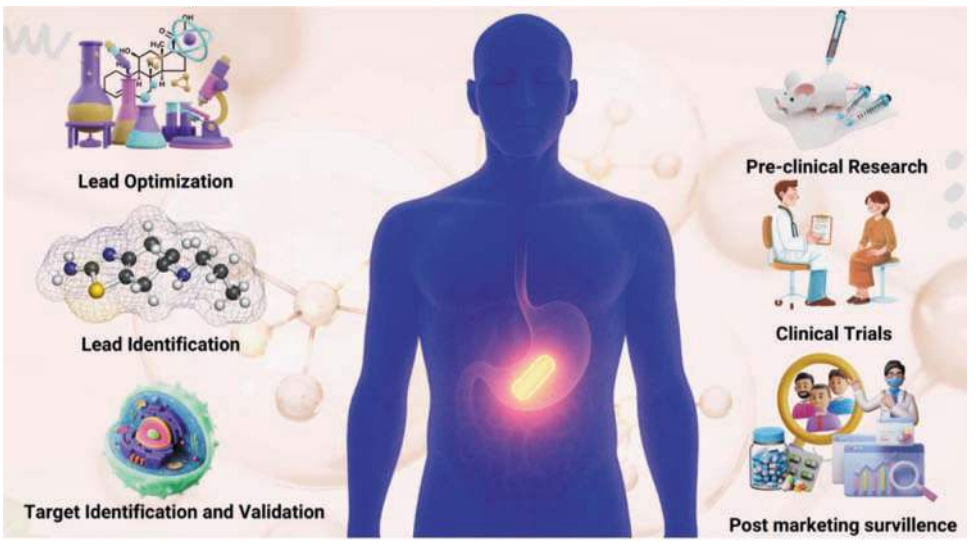


Educational difference between prescriber's vs producers

The APHE conundrum

Recognising this need to root pharmaceutical education in human biology, the All India Council for Technical Education (AICTE) introduced Anatomy, Physiology, and Health Education (APHE) into the B.Pharm. curriculum. Structured in two phases, APHE I focuses on cellular and tissue-level anatomy, while APHE II delves into human organ systems and physiological functions. The objective is clear: to align pharmaceutical training with the biological realities of the human body (14).

Yet the program often falls short, particularly in providing meaningful, hands-on, practical training.



From discovery to surveillance, the patient is at the heart of it all

Medicine is both prescribed and produced. While MBBS students are trained to prescribe medicines, pharmacy students are taught to design them. But the educational journeys that shape these roles are strikingly unequal. Medical students benefit from clinical exposure, patient interaction, and cadaveric dissection. Pharmacy students, by contrast, must rely on plastic models, textbook diagrams, and abstracted illustrations of disease. Histology is rushed. Pathology is mentioned but rarely explored in depth. The result? Many students can describe disease in theory, but struggle to visualise its development and impact within the living system (15).

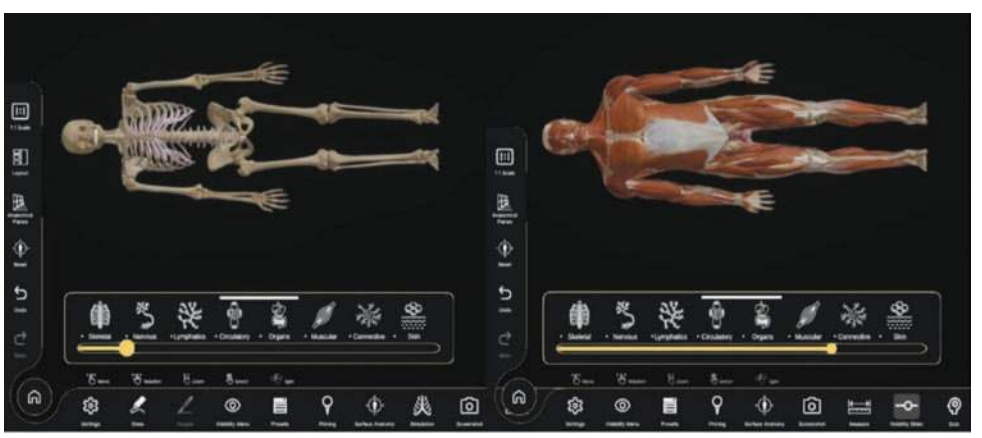
Revolutionising pharmaceutical education with digital innovation

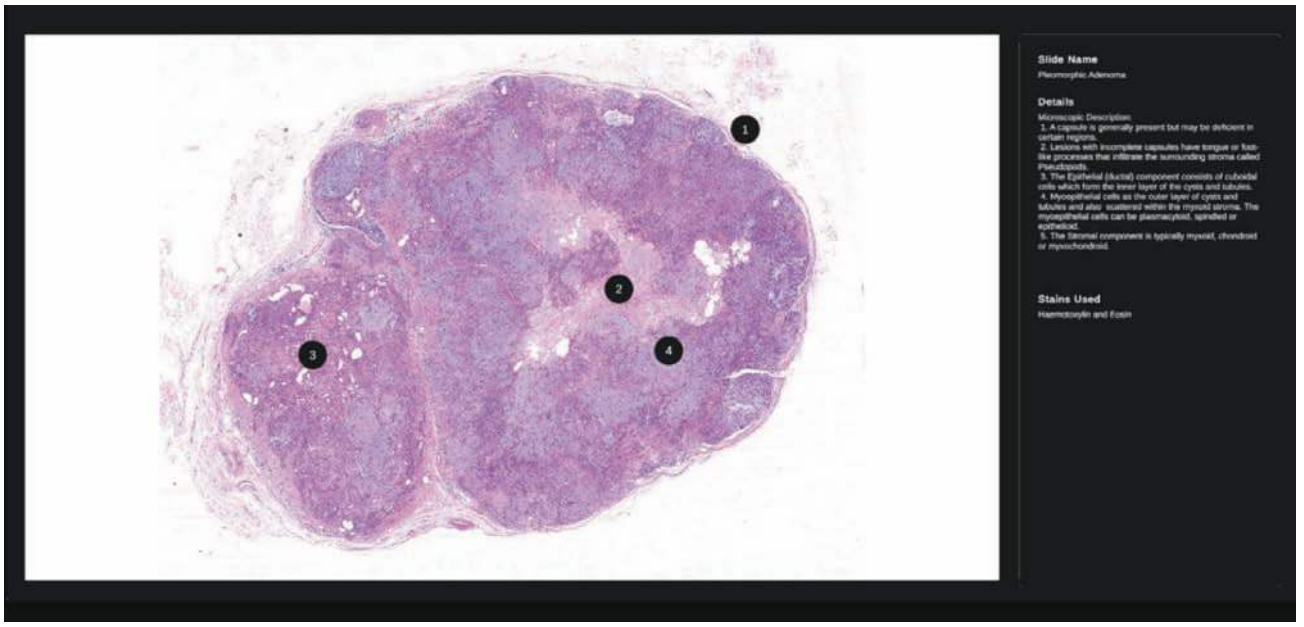
This disconnect between cognitive knowledge and embodied understanding is the APHE conundrum. And the key reasons why drug discovery in India is more theoretical than practical.

So, with cadaveric dissection off the table and clinical immersion out of reach, how do pharmacy students gain meaningful insight into the human body? That's where digital transformation steps in.

Digital innovation in pharma education

In step with the age of AI, the field of pharmacy is adopting digital platforms to stay ahead. It is therefore essential for pharmaceutical academia to equip, next generation of professionals for the digital era of drug discovery and development (16). Among the diverse range of digital technologies available (17), one particularly promising approach for providing meaningful insights into the human body is the integration of an interactive digital dissection table, such as CADAVIZ (18), as a regular part of the pharma curriculum. This system allows for detailed exploration of human anatomy through realistic 3D visualisation, wherein the students can interact with the digital human body in real time to gain a clearer understanding of the crosstalk between various cells, tissues, organs, and organ systems under normal


Visualising anatomy with virtual dissection table



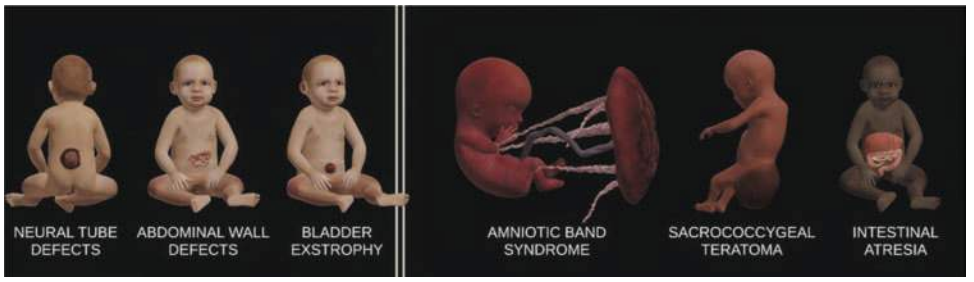
Visualising histopathology with virtual dissection table

physiological and pathophysiological conditions. What distinguishes such digital tools pedagogically is their ability to integrate multiple domains into a unified platform.

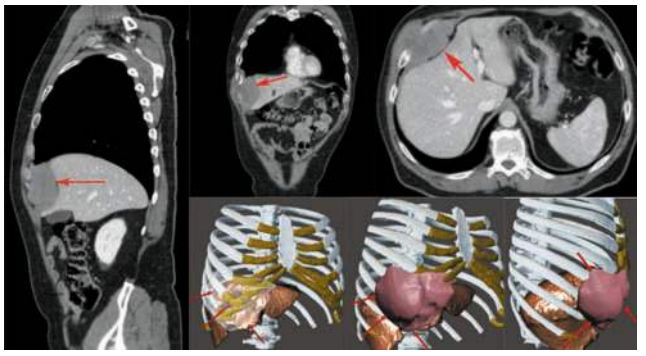
Beyond anatomy, CADAVIZ also integrates physiology, embryology, pathology, histology, and genetics, offering a comprehensive view of human biology. This multidisciplinary approach allows students to move beyond rote memorisation and actively visualise neural and vascular pathways, tracing the routes through which a drug travels following various modes of administration (19).

Using CADAVIZ, pharmacy students can trace the sites of absorption, metabolism, and excretion, as well as the anatomical structures involved in drug binding and those impacted by drug action. This will foster a deeper understanding of how molecular mechanisms relate to their anatomical and physiological contexts.

Students can also explore human microanatomy in vivid detail, learning to distinguish between healthy and diseased tissues with clarity and confidence. This early exposure to histopathological patterns builds a strong foundation for understanding how drugs interact with organs at the cellular level—knowledge that's vital in preclinical research.



Visualising teratogenesis with virtual dissection table



Visualising 3D model of an abdominal desmoid tumor reconstructed from DICOM images, (20)

By observing the microscopic effects of potential treatments, students will be able to gain insight into toxicity, dosage response, and disease progression. More importantly, they learn to recognise the similarities and differences between animal and human systems, equipping them to support the critical transition from lab-based discovery to tailored therapies.

The integration of digital dissection technology will also empower students to explore real patient datasets through a DICOM viewer, providing valuable insights into tumour progression and organ pathology. This visualisation will aid in understanding clinical endpoints, a critical component in designing targeted drug delivery systems. By vividly mapping anatomical targets, students gain a clearer understanding of how drugs can be precisely delivered to affected areas.

Conclusion: Driving change for a new pharmaceutical India

To realise India's true potential in drug discovery, pharmaceutical education must undergo a fundamental transformation. For too long, the focus has remained on production over innovation. But the future demands a cultural reset. Digital tools must move from the periphery to the heart of learning. Technologies such as virtual dissection table do more than teach; they inspire. They prepare a generation of pharmacists to be co-creators in discovery, not just dispensers of the end product. If India is to move from the "Pharmacy of the World" to the "Cradle of Pharmaceutical Discovery," innovation must no longer be an ambition—it must be the foundation.

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