

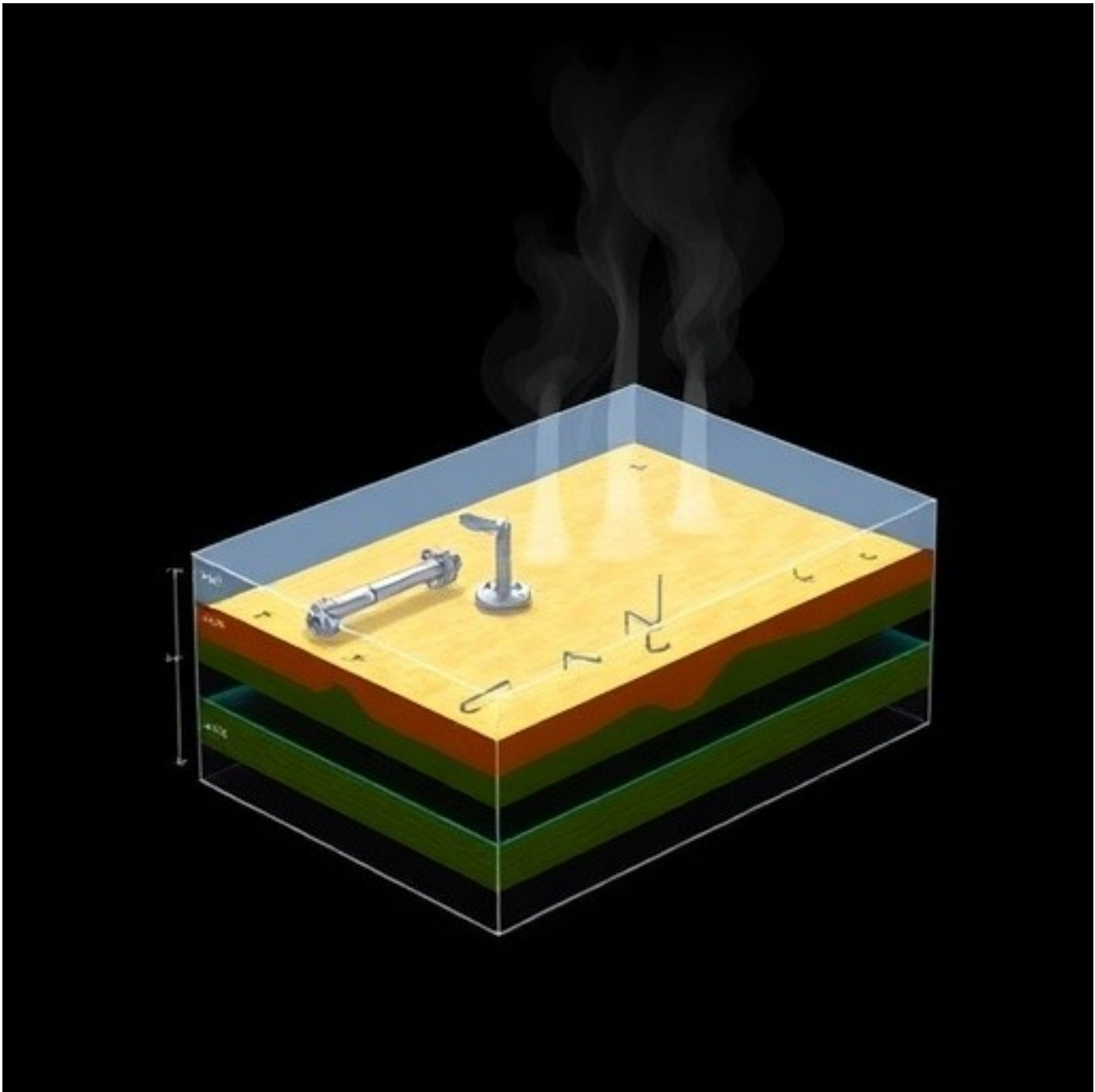
Innovative Database for Subsurface Energy Storage Promises New Opportunities for Natural Gas Sector



BY **BIOENGINEER** — July 2, 2026 in **Technology** Reading Time: 5 mins read

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A groundbreaking study conducted by researchers at The University of Texas at Austin has shed new light on the vast network of underground natural gas storage facilities that underpin the United States' energy infrastructure. This comprehensive geological and engineering analysis presents a crucial resource for enhancing the country's natural gas storage capacity, optimizing existing system [^](#) exploring emerging avenues such as

underground hydrogen and carbon storage. Published in the renowned journal Earth Energy Science, the study pioneers an integrated evaluation of reservoirs, aquifers, and salt caverns used for natural gas storage across the nation.

The United States maintains the world's largest underground natural gas storage network, comprising nearly 400 facilities situated within depleted oil and gas fields, saline aquifers, and engineered salt caverns. Collectively, these reservoirs hold an impressive capacity nearing 9.2 trillion cubic feet, critical for balancing the nation's daily natural gas consumption, which averages around 92 billion cubic feet. As demand for natural gas escalates amid energy transitions, expanding and optimizing subterranean storage infrastructure is paramount to ensuring supply reliability and enhancing energy security.

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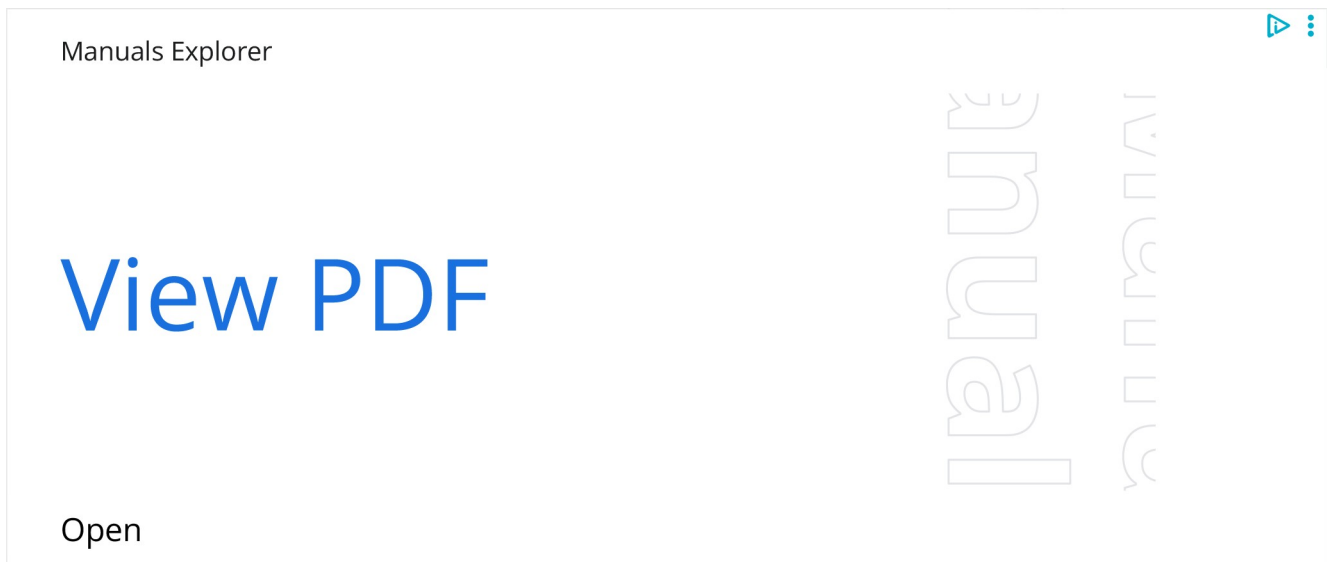
Central to this development is the novel database compiled by researchers led by Abouzar Mirzaei Paiaman from the Bureau of Economic Geology at the UT Jackson School of Geosciences. Unlike previous efforts by the U.S. Energy Information Administration (EIA) and the Pipeline and Hazardous Materials Safety Administration (PHMSA), which offered basic facility-level data, this new resource integrates detailed geological characterizations, reservoir engineering parameters, and operational performance data. This multidisciplinary approach provides a holistic understanding of storage site viability and operational potential, surpassing the capabilities of existing public datasets.





The study's analytical framework evaluates storage sites based on multiple performance metrics, including geological stability, storage capacity, injection and withdrawal rates, and reservoir integrity. These metrics enable stakeholders to assess the suitability of various sites for potential expansion or development of new facilities. Furthermore, the research delineates the distinctions among depleted reservoirs, saline aquifers, and salt caverns, providing insights into their respective technological challenges and benefits. For instance, salt caverns offer rapid injection and withdrawal capabilities, whereas depleted reservoirs benefit from established containment but may have more complex operational constraints.

Beyond natural gas, the implications of this research extend into the burgeoning field of clean energy storage and carbon management. As hydrogen fuel and carbon dioxide sequestration gain prominence in efforts to reduce greenhouse gas emissions, the potential to repurpose underground natural gas storage infrastructure for these new vectors emerges as an innovative strategy. The study highlights that the existing geological formations and operational techniques might be adapted to securely store hydrogen – a carbon-free energy carrier – or permanently sequester CO₂, thereby mitigating atmospheric emissions and supporting climate change mitigation goals.



A particularly intriguing aspect of the study involves the role of “cushion gas” in underground storage facilities. Cushion gas refers to the volume of gas permanently retained in these reservoirs to maintain adequate pressure, ensuring efficient withdrawal when demand surges. Currently, around half of the stored natural gas serves as cushion gas. The researchers suggest that replacing this cushion gas with alternative substances such as CO₂ could unlock more natural gas for productive use and simultaneously provide a geologically secure method for carbon capture and storage (CCS). This dual-purpose innovation exemplifies the synergy between traditional fossil fuel infrastructure and emerging decarbonization technologies.

The research team’s efforts received support from the State of Texas Advanced Resource Recovery (STARR) program, which focuses on sustainable exploitation and profitability of earth resources. The collaboration highlights the importance of aligning geological expertise with energy policy and industry needs to foster resilient and environmentally responsible energy solutions. State and federal efforts aimed at modernizing underground storage capacity stand to benefit greatly from the insights generated by this multidisciplinary analysis.



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Looking forward, the integrated database and its analytical framework pave the way for sophisticated engineering strategies aimed at improving the performance of existing storage facilities. Efforts to enhance reservoir integrity, increase injection and withdrawal efficiency, and incorporate alternative gases as cushion materials could revolutionize the operational economics of underground storage. Such strategies would ensure better responsiveness to fluctuating market dynamics and energy demands, reinforcing the reliability of the natural gas supply chain.

Another noteworthy focus is the exploration of hybrid storage systems that integrate natural gas and hydrogen. Developing safe, efficient, and scalable hydrogen storage within existing geological formations could accelerate the adoption of hydrogen as a mainstream fuel, complementing the country's decarbonization roadmap. Understanding the geochemical interactions and pressure dynamics within these reservoirs is crucial to preventing operational hazards and ensuring long-term storage integrity.

The comprehensive nature of the study also serves as a powerful decision-making tool for energy companies, regulatory bodies, and policy makers. By ranking facilities based on rigorous geoscience-informed criteria, stakeholders can prioritize investments, regulatory approvals, and technological upgrades where they yield the greatest impact. This data-driven approach fosters more transparent and evidence-based management of underground storage assets.



Beyond the immediate technical and operational benefits, the study contributes to national energy resilience, a priority underscored by recent market volatilities and supply disruptions. Having a robust underground storage framework supports seasonal demand shifts, mitigates supply shocks, and undergirds the continued evolution toward a cleaner energy economy. The adaptability of these subterranean systems for multi-commodity storage augments the flexibility and sustainability of energy infrastructure.

The integration of geological assessments with operational data signifies a maturation in energy resource management, where subsurface complexities are no longer viewed as obstacles but as strategic advantages. This holistic understanding empowers operational innovations and fosters synergy between traditional energy sectors and emerging clean energy technologies. As the energy landscape rapidly transforms, the ability to leverage existing natural geological formations for multifaceted storage functions epitomizes a forward-thinking approach to energy security and climate stewardship.

In summary, the study by The University of Texas at Austin offers a landmark contribution to the field of underground energy storage, leveraging geoscience, reservoir engineering, and operational insights to enhance the United States' capacity and capability in natural gas storage. Its implications ripple far beyond fossil fuels, charting a course for integrated storage solutions that support hydrogen fuel adoption and carbon sequestration. This research not only addresses immediate energy storage challenges but also aligns with visionary goals for a resilient, sustainable, and low-carbon energy future.

Article Title: Geoscience-informed evaluation of U.S. natural gas storage reservoirs, aquifers and salt caverns

News Publication Date: 1-Jun-2026



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- <https://doi.org/10.1016/j.ees.2026.100052>
- Bureau of Economic Geology, UT Austin: <https://www.beg.utexas.edu/>
- UT Jackson School of Geosciences: <https://www.jsge.utexas.edu/>

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Keywords

Applied sciences and engineering, Energy resources, Fossil fuels, Natural gas, Hydrogen fuel, Underground gas storage, Carbon capture and storage, Salt caverns, Saline aquifers, Reservoir engineering, Energy infrastructure, Subsurface geological analysis

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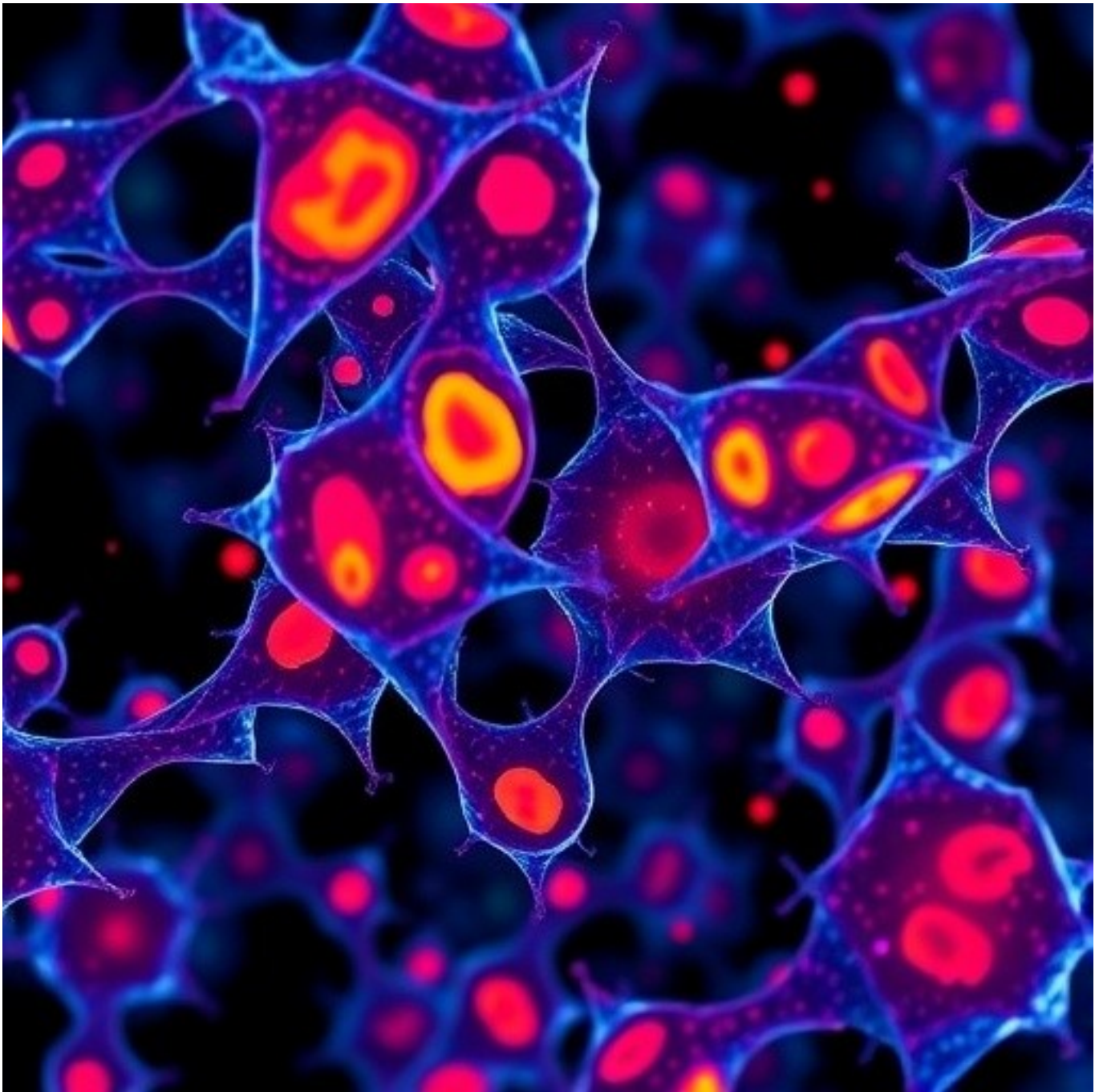
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Mapping Cancer-Fighting Antibodies in Human Tumors with Unmatched Precision

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A Revolutionary Lens Into the Tumor Microenvironment: Mapping Antibody Distribution at Single-Cell Resolution

The fight against cancer has seen remarkable advances through antibody-based therapies, offering hope especially in hematologic malignancies and certain breast cancers. Yet, this

promising avenue stumbles when confronting solid tumors; mere one-fifth of these invasive cancers respond effectively to antibody treatments. A central enigma remains: Do these therapeutic antibodies truly reach their intended cellular targets deep within the dense tumor architecture? Researchers at Stanford Medicine have now unveiled an innovative method that not only reveals the exact whereabouts of antibodies within tumors but also deciphers the intricate cellular interactions influencing their efficacy.

Traditional imaging techniques like positron-emission tomography (PET) scans have offered little more than vague, blurry “hot spots,” indicating the general region of antibody presence but failing to delineate whether the drug is ensconced within the bloodstream, trapped in extracellular matrices, or genuinely engaging cancerous cells. This limitation has hampered the understanding of therapeutic outcomes, leaving clinicians to speculate on the mechanistic reasons behind treatment failure.

The newly developed approach, termed single-cell spatial pharmacobiology (SSP), merges the power of advanced multiplexed protein detection with precise fluorescent antibody tagging. At its core lies the CODEX technology, pioneered by Professor Garry Nolan's lab, capable of simultaneously imaging over fifty protein markers within a single tumor tissue slice. When combined with a fluorescent tag attached to the therapeutic antibody, this method maps antibody localization onto a high-definition protein landscape with astonishing precision—aligning cellular boundaries within one micrometer, essentially to the scale of individual subcellular compartments.

Applying SSP to real-world clinical samples from patients undergoing novel fluorescently guided surgeries at Stanford, the researchers uncovered striking heterogeneity in antibody penetration across tumor types. Head and neck squamous cell carcinomas, modest responders to immunotherapy, exhibited relatively higher drug infiltration compared to the notoriously fibrotic and treatment-resistant pancreatic tumors. Even within head and neck tumors, antibody distribution was uneven; only about 16% of cancer cells expressing the epidermal growth factor receptor (EGFR), the antibody's target, were effectively bound by the drug. These engaged cells predominantly nestled at the tumor periphery adjacent to vascular structures, suggesting a physical bottleneck obstructing drug access to tumor cores.

Delving deeper, analyses revealed that the tumor microenvironment plays a decisive role in modulating antibody delivery. Dense network of stromal elements — particularly cancer-

associated fibroblasts and extracellular matrix proteins like periostin — form formidable physical barricades around tumors. Periostin, a structural protein typically found in tendons and bones, was prevalent in a mesh-like arrangement encapsulating tumor regions with poor antibody penetration. Moreover, a specific fibroblast subtype, capable of producing matrix components including periostin, correlated strongly with these impermeable barriers. This detailed insight uncovers a mechanism by which stromal architecture actively impedes therapeutic efficacy.

Crucially, SSP offers more than just static visualization; it provides a nuanced pharmacological assessment, allowing researchers to determine not only where antibodies accumulate but whether the drug binds to its intended target and exerts anticipated biological effects. Previously, measurement methods relying on plasma antibody levels or radioactive labeling failed to parse such intricate details. By illuminating the precise cellular neighborhoods accessible to drugs, SSP paves the way for rational design of adjunct therapies aimed at dismantling stromal defenses and enhancing antibody delivery.

The implications extend well beyond head and neck or pancreatic cancers. Many solid tumors harbor complex microenvironments whose physical and biochemical landscapes remain poorly understood yet critically influence therapeutic outcomes. With SSP, researchers now have an unprecedented tool to dissect these landscapes comprehensively. It invites a future where cancer treatment becomes highly personalized, informed by spatial pharmacological

maps guiding clinicians in predicting response and tailoring combinational strategies.

This breakthrough is also a testament to the transformative potential of interdisciplinary collaboration. The integration of fluorescently labeled therapeutic antibodies from clinical trials with molecular imaging and computational alignment algorithms demonstrates how convergence across clinical oncology, molecular pathology, and bioinformatics can redefine research paradigms. Teams from across renowned institutions including Vanderbilt University Medical Center, Duke University, and international centers contributed their expertise to this pioneering work.

Funding support from the National Institutes of Health and other prominent organizations underscores the importance and promise of this work, propelling forward the frontiers of cancer pharmacology. As SSP technology matures, it holds promise not just for mapping antibody drugs, but potentially other classes of targeted therapies, opening vistas for improved diagnostics, monitoring, and treatment optimization.

By revealing the hidden interplay between therapeutic antibodies and the tumor microenvironment at microscopic resolution, Stanford researchers illuminate a critical bottleneck in cancer treatment. Their innovative single-cell spatial pharmacobiology approach marks a transformative leap toward more effective, tailored immunotherapies that can overcome the stromal barriers thwarting drug delivery. It is a beacon of precision medicine, bringing us closer to fundamentally understanding and conquering solid tumors that have long eluded therapeutic success.

Subject of Research: Cells

Article Title: Single-cell spatial pharmacobiology identifies conserved stromal barriers to therapeutic antibody delivery in human solid tumors

News Publication Date: July 3, 2026

Web References:

<https://doi.org/10.1038/s41587-026-03152-x>

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Lu, G. et al. Single-cell spatial pharmacobiology identifies conserved stromal barriers to therapeutic antibody delivery in human solid tumors. *Nature Biotechnology* (2026).

Keywords: Cancer cell phenotypes, antibody delivery, tumor microenvironment, spatial

pharmacobiology, immunotherapy resistance, extracellular matrix, stromal barriers, fluorescent imaging, CODEX technology, pancreatic cancer, head and neck squamous carcinoma

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