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Editorial

Welcome to *ACS Nano Medicine*: From Nanoscale Innovation to Clinical Impact

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Paul Ehrlich's early 20th century "magic bullet" (Zauberkugel) concept articulated a transformative vision for medicine, i.e., therapies that precisely target disease while minimizing collateral damage. A century later, nanomedicine has emerged as a powerful realization of this idea, harnessing nanoscale carriers to deliver potent drugs and/or contrast probes selectively to pathological cells. The field has matured from a largely exploratory discipline into a translational engine that is reshaping how we diagnose, monitor, and treat disease. What began as an effort to exploit size-dependent physicochemical phenomena has evolved into a sophisticated convergence of materials science, chemistry, biology, engineering, and clinical medicine. As we enter the next phase of growth, the field faces both unprecedented opportunity and necessary recalibration.

ACS Nano Medicine, the newly launched journal from the American Chemical Society, sits at this technological inflection point charged with capturing foundational advances while setting a clear vision for clinical translation. The journal welcomes studies that not only advance nanoscale science but also illuminate the biological, engineering, and regulatory parameters essential for real-world impact. By embracing work that bridges fundamental discovery and translational application, *ACS Nano Medicine* seeks to accelerate the development of nanotechnologies that meaningfully improve patient outcomes. Over the past decade, the field has witnessed tangible clinical successes. During the COVID-19 pandemic, lipid nanoparticles enabled the rapid deployment of mRNA vaccines at global scale. Nanostructured contrast agents have expanded molecular imaging beyond anatomy into functional and molecular domains. Nanoenabled biosensors are beginning to move diagnostics from centralized laboratories to clinics, homes, and resource-limited settings. These achievements validate the central promise of nanomedicine: that rational nanoscale design can unlock biological performance not achievable with conventional materials. As of 2025, there are approximately 563 nanomedicines in active clinical trial phases or other clinical processes (https://clinicaltrials.gov/). This statistic includes completed recruitment, active, and other trial statuses. Most trials remain in Phase I/II, with relatively few advancing to Phase III or beyond, reflecting enduring translational challenges in nanomedicine. Importantly, however, the collective impact of these studies extends well beyond individual approvals − sharpening our understanding of biological complexity, manufacturability, and clinical integration, and helping to define design principles that are now accelerating the next generation of successful nanomedicines.

Over the past year, the field has confronted hard realities as many elegant nanomaterials have struggled to progress beyond proof-of-concept. Challenges related to reproducibility and quality control, product manufacturing and scalability, biological complexity, regulatory pathways, and integration into real-world clinical workflows and care pathways have slowed translation. Rather than signaling failure, these realities mark a long-anticipated transition from a predominantly discovery-driven enterprise to a more mature translation-focused phase. The future of nanomedicine will be defined not by novelty of nanomaterials alone, but by mechanistic clarity, robustness, and clinical relevance.

Looking forward, several themes are poised to define the next decade of nanomedicine. First, a deep mechanistic understanding of nanobio interactions must take center stage. High-impact nanomedicine research must rigorously connect nanoscale structure, morphology, dynamics, and interfacial chemistry to biological function. This includes quantitative understanding of nanobio interactions, transport phenomena, pharmacokinetics and pharmacodynamics, immune engagement, metabolic processes, and degradation pathways across tissues and cellular compartments. Studies that integrate theory, modeling, and advanced characterization with biological validation will be essential to move the field beyond empirical optimization. Second, the convergence of nanomedicine with other emerging fields will accelerate translation. The most promising advances increasingly arise at disciplinary interfaces, for example, nanomaterials combined with synthetic biology, artificial intelligence (AI), immunology and immunometabolism, systems biology, advanced manufacturing, and clinical sciences. Data-driven design, automated synthesis, and machine-learning (ML)-guided optimization are emerging to reduce development cycles, enhance reproducibility, and enable more predictive structure−function relationships. In parallel, closer partnerships with clinicians and regulatory experts are reshaping how nanotechnologies are conceived from the outset, aligning innovation with unmet medical needs and feasible deployment pathways. From an application standpoint, while drug delivery remains central,

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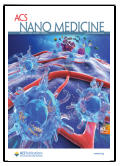

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nanoenabled sensing, imaging, theranostics, and continuous monitoring are rapidly expanding the scope of nanomedicine. Wearable, implantable, and at-home diagnostic platforms that leverage plasmonic, electronic, and nanophotonic architectures are set to redefine disease detection and management. These technologies position nanomedicine not just as an interventional tool, but as a foundation for precision and preventive healthcare.

Manufacturability and scalability are no longer secondary considerations; materials that cannot be produced reproducibly, characterized rigorously, and scaled for human use will be less impactful regardless of performance. Future breakthroughs will increasingly emphasize synthesis control, quality assurance, and lifecycle considerations. Sustainability, cost, and supply chain resilience are becoming integral components of nanomedical design, particularly as technologies move toward global deployment. The lasting impact of nanomedicine is judged not by academic metrics, but by the extent to which it improves lives across diverse populations. Technologies that simplify workflows, reduce infrastructure dependence, and function in real-world environments will play a critical role in closing gaps in healthcare access. Nanomedicine must be globally relevant, not selectively transformative. Technologies that can be readily manufactured, distributed, and easily deployed in low-resources settings have the potential to deliver high impact to the field.

ACS Nano Medicine is committed to serving as a leading platform for this next phase of the field. We seek contributions that are mechanistically grounded, quantitatively rigorous, and visionary work that connects discovery and application while maintaining the highest standards of scientific integrity. We particularly encourage submissions that challenge existing paradigms, integrate disciplines, and articulate clear pathways toward clinical translation. Through carefully curated content, original research articles, perspectives, reviews, and viewpoints, the journal endeavors to chart the evolving landscape of nanomedicine and to foster a community committed to responsible innovation and global health relevance. As the field continues its rapid expansion, *ACS Nano Medicine* will serve as both a compass and a catalyst: defining standards, spotlighting breakthroughs, and guiding the field toward impactful clinical translation. We invite you to join us on this journey, whether as an opinion leader, author, reviewer, or reader, in shaping a journal that drives rigorous, interdisciplinary research required to turn nanoscale discoveries into clinically relevant, globally accessible solutions.

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