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Editorial: Progress in the application of biomaterials and nanotechnology in cell biology

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Editorial on the Research Topic
Progress in the application of biomaterials and nanotechnology in cell biology

The integration of biomaterials and nanotechnology is revolutionizing cell biology, as exemplified by the pioneering studies in this Research Topic. Exosome-mediated co-delivery of curcumin and methylene blue (Yang et al.) demonstrates synergistic neuroprotection in Alzheimer's models, leveraging exosomes' blood-brain barrier permeability to modulate autophagy and reduce amyloid-β toxicity. Simultaneously, mechanobiology insights emerge from adipose regeneration research (Ye et al.), where dynamic force transduction activates YAP/β-catenin signaling, guiding scaffold design for transplanted adipocyte survival. Complementing therapeutic innovation, fluorescent carbon dots (CDs) within PEC-GS/BG hybrids (Zhang et al.) achieve real-time cellular tracking with minimal cytotoxicity, exemplifying how nanoscale optical probes illuminate intracellular dynamics. Theranostic convergence is further evident in miRNA-nanomedicine systems (Telkoparan-Akillilar et al.), where tumor-targeted nanoparticles exploit endogenous regulatory pathways for combinatorial gene/chemotherapy, while precision nanomedicine advances (Mao et al.) highlight biomarker-responsive nanomaterials enabling patient-specific cancer diagnosis and treatment.

Collectively, these studies underscore certain transformative trends, including multifunctionality in nanocarriers, bidirectional material-cell communication, and closed-loop diagnostic-therapeutic integration. Future progress hinges on decoding nano-bio interfaces at single-cell resolution and establishing scalable biomaterial manufacturing (Liu et al., 2023). As spatial omics and AI-driven design mature, next-generation platforms will likely transcend traditional compartmentalization, enabling real-time adaptation to cellular microenvironments (Jiang et al., 2025). This Research Topic crystallizes a pivotal shift toward predictive and participatory nanomedicine-where materials actively collaborate with biological systems to restore function.

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