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# Bioengineering goes environmental



**Biomedical engineering innovations are being reimagined to address climate and environmental challenges, from food safety and crop engineering to plastic degradation and soil remediation.**

Bioengineering is breaking disciplinary boundaries, with tools once confined to biomedicine now driving solutions for food security, pollution and ecosystem resilience; importantly, this exchange could work both ways.

Gene and genome engineering have fundamentally reshaped methodologies in biomedicine and molecular biology. The same precision genetic engineering tools, refined in eukaryotic and prokaryotic cells, can be redesigned to modify plants and crops[1,2] – for example, to make them more resilient against climate change or improve their nutritional profile. Similarly, biosensing technologies, originally optimized for point-of-care disease diagnosis, can be adapted for on-site detection of pathogens in food products and the environment[3,4], or integrated into smart food packages[5]. In addition, nanotechnologies, initially developed for delivery, sensing and imaging in microbial and animal systems, also enable direct germline editing as well as plastid and mitochondrial genome modification in plants[6]. Biomanufacturing is also crossing domains, with bioprinting strategies from tissue engineering now used for cultivated meat production[7]. Such cellular agriculture approaches might contribute to meeting future food demands and achieving the United Nations Sustainable Development Goals, if developed and applied sustainably, as argued by Mehran Ghasemlou et al. in a Comment in this issue.

Bioengineering might also have a key role in tackling plastic pollution by enabling re-engineering of natural enzymatic processes for biocatalytic purposes. For example, microbial hydrolases can be designed to depolymerize polyesters under process-relevant conditions for a circular plastics economy[8]. However, addressing plastic pollution requires more than improved waste management; it demands a deeper understanding of how different plastic types affect health and ecosystems. In a Review article in this issue, Jian Zhao et al. outline strategies for detecting, identifying and quantifying micro- and nanoplastics in biological samples. Their discussion spans workflows for sample digestion, particle separation and enrichment, as well as advanced labelling techniques that improve visualization and counting accuracy. Notably, similar principles of particle isolation, tracking, enrichment and imaging protocols could be adapted to monitor therapeutic nanoparticles in complex animal and human tissues to improve pharmacokinetic profiling and biodistribution analysis.

> **"Bioengineering is breaking disciplinary boundaries, with tools once confined to biomedicine now driving solutions for food security, pollution and ecosystem resilience"**

Environmental contamination is a concern not only related to organisms but also to croplands and soil. In a Review article in this issue, Ravi Naidu et al. suggest bioengineering strategies to mitigate heavy metal pollution at the ecosystem scale, including physical barriers through soil amendment materials and genetic engineering of plants and microorganisms, such as in situ soil microbiome engineering and enhancement. Such multi-scale environmental interventions for contaminated landscapes could inspire more holistic approaches in healthcare, whereby symptoms, pathogenesis and treatments are considered in tandem with microbiome dynamics and host–environment interactions.

Even if some ideas seem futuristic and/or unrealistic, the effort to seek tools, concepts and design strategies across domains is valuable per se. Bioengineers' strengths should not only lie in technical innovation but also in their ability to recognize and repurpose solutions across scales and sectors.

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