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Editorial

Biomaterials and Natural Products: Nature's Contributions to Heath Care and Everyday Applications

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Natural products and biomaterials have long shaped medicine, from early remedies for infection and cancer to today's drug discovery pipelines and advanced medical materials. Phytomedicine remains vital in low-income countries, whereas in high-income settings, bio-derived compounds increasingly serve as leads, adjuvants, and functional components. Renewed interest reflects urgent needs, including antimicrobial resistance, chronic wounds, inflammatory diseases, and the demand for sustainable, biocompatible solutions. Their value lies in complementing modern therapies, positioning nature's molecular and structural diversity as a partner to medicine. Examples include Manuka honey with antimicrobial activity; mushrooms and dandelion with reported anticancer potential; and abundant biopolymers such as cellulose and chitin/chitosan. Cotton remains central to medical textiles, while chitosan's intrinsic antimicrobial properties are already applied in toothpaste and military bandages. These cases illustrate how biodiversity and abundance translate into practical, accessible innovations across both low- and high-income settings.

Natural products remain a rich source of antimicrobials, from honey and garlic to oregano and turmeric, each acting through diverse mechanisms. Carbon dots derived from agricultural waste exemplify sustainable innovation, combining antimicrobial activity with tunable optical properties for coatings and wound dressings. Natural compounds also serve as resistance-modifying agents and continue to shape oncology, with drugs such as paclitaxel and vincristine originating from nature. Natural agents such as omega-3 fatty acids, flavonoids, and capsaicin, together with regulatory cytokines, can modulate immune signaling and reduce tissue damage. Their greatest value often lies as supportive therapies, enhancing healing and tolerance when combined with antimicrobial or anticancer treatments. Natural extracts such as *Centella asiatica* and *Curcuma longa* accelerate repair when incorporated into dressings, hydrogels, or scaffolds. Transdermal systems based on natural compounds provide localized, sustained delivery, improving efficacy while reducing systemic side effects. Recent advances show that biosurfactants can be engineered not only for dispersion and biofilm disruption but also with direct antimicrobial and antifungal activity, expanding their role in wound care, coatings, and drug delivery. These molecules, produced by microbes or derived from renewable feedstocks, add functional layers of protection and therapeutic action to biomaterial systems.

Biopolymers—cellulose, chitosan, alginate, gelatin, collagen, PLA, and related materials—are central to sustainable medical technologies. Chitosan, with broad antimicrobial activity, is often modified or combined with plant extracts and nanoparticles to tailor performance. Biosurfactants add functionality by disrupting biofilms and improving drug delivery, making them valuable in wound care and device coatings. Such bio-based polymers yield sutures with biocompatibility and controlled degradation, minimizing foreign-body responses. Advanced grafts and scaffolds integrate antibiotics or bioactive compounds, enabling localized infection control and tissue regeneration. These systems exemplify the shift from passive closure to bioactive wound management. In parallel, biopolymers such as xanthan, pullulan, and carrageenan are gaining attention as sustainable, biocompatible scaffolds. Xanthan gum provides viscosity and stability for topical formulations; pullulan offers film-forming and oxygen-impermeable properties useful in wound dressings and oral delivery; and carrageenan, derived from red seaweed, combines gelling capacity with antiviral and immunomodulatory potential. Together, these polymers extend the biomaterial toolkit beyond structural reinforcement, enabling multifunctional systems that integrate antimicrobial, anti-inflammatory, and regenerative properties.

Marine polysaccharides such as alginate, carrageenan, agar, and chitosan derivatives provide biocompatible platforms for wound dressings, drug delivery, and tissue engineering, while marine microorganisms enable sustainable biosynthesis of functional materials. Recent work highlights engineered marine systems capable of producing nanomaterials, including biologically synthesized magnetic iron nanoparticles with controlled size and surface properties. Beyond materials, marine-derived metabolites continue to supply novel bioactive scaffolds for antimicrobial, anticancer, and anti-inflammatory drug discovery. Together, marine bioproducts bridge polymers, nanomaterials, and pharmaceuticals, underscoring the ocean's growing role in health care, biotechnology, and sustainable manufacturing.

Beyond medical applications, antimicrobial polymers are increasingly important in food packaging, where they extend shelf life and reduce contamination risks. Natural and bio-based polymers such as chitosan, cellulose derivatives, starch blends, and polylactic acid (PLA) can be functionalized with plant extracts, essential oils, peptides, or nanoparticles to inhibit bacterial and fungal growth directly at the food surface. These systems combine biodegradability and safety with active protection, offering alternatives to synthetic preservatives and plastics. By integrating antimicrobial activity into packaging films and coatings, bio-derived polymers help ensure food quality, reduce waste, and align with sustainability goals—demonstrating how functional biomaterials can impact both healthcare and consumer products. Purified lipids and glycerides extracted from agricultural byproducts have been shown to prolong the freshness of fruits such as avocados, citrus, and cucumbers. This provides a practical example of how biomaterials and biotechnology converge in consumer products to address global challenges in food security and sustainability.

Metal and metal-oxide nanoparticles further enhance antimicrobial performance. Silver nanoparticles remain the benchmark, but cost and toxicity concerns drive interest in alternatives such as zinc oxide and copper oxide. Cerium oxide (CeO_2) is of particular interest because of its redox-active behavior, combining antimicrobial, anti-inflammatory, and cytoprotective functions. Embedding these nanoparticles in chitin/chitosan or cellulose matrices enables controlled release and localized activity.

Artificial intelligence (AI) increasingly streamlines natural product screening and supports biomaterial and device design. One of the most striking developments is its role in antibiotic discovery: breakthroughs such as halicin and abaucin demonstrated low minimum inhibitory concentrations, novel mechanisms of action, and minimal toxicity, highlighting how machine learning can repurpose overlooked molecules and identify new scaffolds against multidrug-resistant pathogens. Chitin/chitosan, cellulose nanofibers, and other biopolymers provide versatile platforms for biofunctional materials that combine antimicrobial activity, mechanical strength, and controlled delivery. Guided by AI-driven design, these systems support scalable solutions for wound care and medical devices. The growing prevalence of multidrug-resistant pathogens, from extensively resistant *Escherichia coli* to drug-resistant *Mycobacterium tuberculosis*, underscores the urgency of such approaches.

The future of biomaterials lies not only in their antimicrobial promise but in their broader role as functional platforms integrating anti-inflammatory, wound-healing, and regenerative properties. From medical textiles and consumer products to advanced drug delivery systems, bio-derived polymers will increasingly serve as adaptable scaffolds that unify durability, biocompatibility, and therapeutic function. Coupled with AI-enabled design and screening, these materials can be engineered with precision—tailoring mechanical strength, release kinetics, and biological activity to specific clinical and consumer needs. This convergence of nature's toolkit and computational innovation positions biomaterials as a cornerstone of next-generation medicine, where therapies are not only effective against infection but also actively promote healing, resilience, and sustainability across healthcare and everyday applications.

Conflicts of Interest

Given the role as the Editor-in-Chief, John H. T. Luong had no involvement in the peer review of this paper and had no access to information regarding its peer-review process. Full responsibility for the editorial process of this paper was delegated to another editor of the journal.

Use of AI and AI-Assisted Technologies

The author acknowledges the use of AI-assisted language tools to support editing (ChatGPT) and condensation (Copilot) of the manuscript. The scientific content, interpretation, and final wording remain the sole responsibility of the author.