3D Printed Nano-Bionic Organs

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The development of approaches for multidimensional integration of functional electronic components with biological tissue and organs could have tremendous impact in regenerative medicine, smart prosthetics, and human-machine interfaces. However, current electronic devices and systems are inherently two dimensional and rigid, thus prohibiting seamless meshing with three-dimensional, soft biology. The ability to three-dimensionally interweave biological tissue with functional electronics could enable the creation of bionic organs for restoring impairments, or enhancing human functionalities over their natural limitations. Current electronics are inherently two-dimensional, preventing seamless integration with biology, as the processes and materials used to create synthetic tissue constructs vs. conventional electronic devices are very different. Here, we present a novel strategy for overcoming these difficulties via additive manufacturing of biological cells with various classes of functional electronic nanomaterials. Recently, we have generated a functional bionic ear via 3D printing of a cell-seeded hydrogel matrix in the precise anatomic geometry of a human ear, along with an intertwined conducting polymer consisting of infused silver nanoparticles. This allowed for the *in vitro* culturing of cartilage tissue around an inductive coil antenna in the ear, which subsequently connects to cochlea-shaped electrodes. The printed ear exhibits enhanced auditory sensing for radio frequency reception, and complementary left and right ears can listen to stereo music. Here, we propose extending this approach to new functionalities – such as ultrasonic acoustic reception and vasculature – and new bionic organs. Overall, our approach presents a disruptive and paradigm-shifting new method to intricately merge biology and electronics via 3D printing. The work outlined here thus constitutes a novel, highly interdisciplinary investigation to addressing outstanding questions in the generation of bionic organs, and we anticipate that this work will represent a paradigm-shift in both tissue engineering, as well as 3D interweaving of functional electronics into biological systems.