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Miniature Soft Robotic Systems Towards Complex Fluidic Environments

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The emerging field of miniature soft robots with unprecedented maneuverability, adaptation, and safe interactions with surrounding environments has endowed new platforms to overcome critical challenges in hard-to-reach marine and biomedical scenarios. Focusing on system-level construction, we first synergized soft actuators and bio-inspired structures to create small-scale soft robots emulating larval zebrafish and jellyfish. A class of magnetically actuated laval fish-like milliswimmers was investigated to unveil the mechanism of accomplishing energy-efficient propulsion in the intermediate flow regime. Then, electrohydraulically actuated jellyfish-like platforms were developed to realize further practical underwater functions, such as both contactless and contact-based object manipulation, steering, team operations, and outdoor untethered swimming, besides their fast, energy-efficient, and silent propulsion. Next, using similar small-scale robotics techniques, we developed wireless soft devices and the associated systems for practical biomedical functions, such as local anchoring, on-demand drug delivery, and flow diversion, in distally tortuous tubular structures with fluids of human bodies. Overcoming the fundamental challenges on a small scale will help achieve the overarching goal of intelligent miniature soft systems for robust and reliable real-world utility in biomechanics, marine robotics, biomedical applications, and beyond.