Protein-Engineered Materials for Regenerative Medicine

Wednesday, Sept. 30
1037 Emerging Technologies Building
9:10 a.m.

Stem cell transplantation is a promising therapy for a myriad of debilitating diseases and injuries; however, current delivery protocols are inadequate. Transplantation by direct injection, which is clinically preferred for its minimal invasiveness, commonly results in less than 5 percent cell viability, greatly inhibiting clinical outcomes. We demonstrate that mechanical membrane disruption results in significant acute loss of viability at clinically relevant injection rates. As a strategy to protect cells from these damaging forces, we show that cell encapsulation within hydrogels of specific mechanical properties will significantly improve viability. Building on these fundamental studies, we have designed a family of injectable, bioresorbable, customizable hydrogels using protein-engineering technology. In our Mixing-Induced Two-Component Hydrogel (MITCH), network assembly is driven by specific and stoichiometric peptide-peptide binding interactions. By integrating protein science methodologies with simple polymer physics models, we manipulate the polypeptide chain interactions and demonstrate the direct ability to tune the material properties. This is in contrast to many other physical hydrogels, where predictable tuning of bulk mechanics from the molecular level remains elusive due to the reliance on non-specific and non-stoichiometric chain interactions for network formation. Furthermore, the hydrogel network can be easily modified to deliver a variety of bioactive payloads including growth factors, peptide drugs, and hydroxyapatite nanoparticles. Through a series of in vitro and in vivo studies, we demonstrate that these materials may significantly improve transplanted stem cell retention and function.

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Sarah Heilshorn is associate professor with tenure in the Materials Science and Engineering Department and, by courtesy, the Bioengineering Department and Chemical Engineering Department at Stanford University. Prior to joining Stanford in 2006, Heilshorn was a postdoctoral scholar in molecular and cell biology at the University of California, Berkeley. She completed her Ph.D. and M.S. studies in chemical engineering at the California Institute of Technology in 2004 and 2000, respectively. She earned a B.S. in chemical engineering at the Georgia Institute of Technology in 1998. She combines these diverse fields to design new materials that mimic those found in our bodies for applications in tissue engineering and regenerative medicine. Her work has been recognized with the Career Award from the National Science Foundation and the New Innovator Award from the National Institutes of Health.