Sarah Heilshorn
Associate Professor of Materials Science and Engineering and, by courtesy, of Chemical Engineering and of Bioengineering

CONTACT INFORMATION

• Administrator
  Naomi Tudor - Administrative Associate
  Email  ntudor@stanford.edu

Bio

Heilshorn's interests include biomaterials in regenerative medicine, engineered proteins with novel assembly properties, microfluidics and photolithography of proteins, and synthesis of materials to influence stem cell differentiation. Current projects include tissue engineering for spinal cord and blood vessel regeneration, designing injectable materials for use in stem cell therapies, and the design of microfluidic devices to study the directed migration of cells (i.e., chemotaxis).

ACADEMIC APPOINTMENTS

• Associate Professor, Materials Science and Engineering
• Associate Professor (By courtesy), Chemical Engineering
• Associate Professor (By courtesy), Bioengineering
• Member, Bio-X
• Member, Cardiovascular Institute
• Member, Child Health Research Institute
• Affiliate, Precourt Institute for Energy
• Faculty Fellow, Stanford ChEM-H
• Member, Stanford Neurosciences Institute

HONORS AND AWARDS

• New Innovator Award, National Institutes of Health (2009)
• CAREER Award, National Science Foundation (2009)
• New Investigator Award, Petroleum Research Fund, American Chemical Society (2009)

PROFESSIONAL EDUCATION

• PhD, Caltech , Chemical Engineering (2004)
• MS, Caltech , Chemical Engineering (2000)
• BS, Georgia Tech , Chemical Engineering (1998)
LINKS

- Heilshorn Laboratory Site: http://www.stanford.edu/group/heilshorn/

Research & Scholarship

CURRENT RESEARCH AND SCHOLARLY INTERESTS

Protein engineering
Tissue engineering
Regenerative medicine
Biomaterials

Teaching

COURSES

2017-18
- Bioengineering Materials to Heal the Body: MATSCI 81N (Aut)
- Biomaterials in Regenerative Medicine: BIOE 361, MATSCI 381 (Spr)
- Introduction to Materials Science, Biomaterials Emphasis: ENGR 50M (Win)

2016-17
- Bioengineering Materials to Heal the Body: MATSCI 81N (Aut)
- Biomaterials in Regenerative Medicine: BIOE 361, MATSCI 381 (Spr)
- Introduction to Materials Science, Biomaterials Emphasis: ENGR 50M (Win)
- Introductory Science of Materials: OSPPARIS 50M (Spr)

2015-16
- Organic and Biological Materials: MATSCI 190, MATSCI 210 (Spr)

2014-15
- Biomaterials in Regenerative Medicine: BIOE 361, MATSCI 381 (Aut)
- Introduction to Materials Science, Biomaterials Emphasis: ENGR 50M (Win)
- Materials Science Colloquium: MATSCI 230 (Win)
- Organic and Biological Materials: MATSCI 190, MATSCI 210 (Spr)

STANFORD ADVISEES

Doctoral Dissertation Reader (AC)
- Doreen Chan, Aleksandra Denisin, Alexander Stahl

Postdoctoral Faculty Sponsor
- Michael Kratochvil, Laura Marquardt, Abbygail Palmer

Doctoral Dissertation Advisor (AC)
- Daniel Hunt, Brad Krajina

Postdoctoral Research Mentor
- Laura Marquardt
GRADUATE AND FELLOWSHIP PROGRAM AFFILIATIONS

- Bioengineering (Phd Program)
- Stem Cell Biology and Regenerative Medicine (Phd Program)

Publications

PUBLICATIONS

- Microfluidic Investigation of BDNF-Enhanced Neural Stem Cell Chemotaxis in CXCL12 Gradients SMALL
  Xu, H., Heilshorn, S. C.
  2013; 9 (4): 585-595

- Building stem cell niches from the molecule up through engineered peptide materials NEUROSCIENCE LETTERS
  Lampe, K. J., Heilshorn, S. C.
  2012; 519 (2): 138-146

- Improving Viability of Stem Cells During Syringe Needle Flow Through the Design of Hydrogel Cell Carriers TISSUE ENGINEERING PART A
  Aguado, B. A., Mulyasasmita, W., Su, J., Lampe, K. J., Heilshorn, S. C.
  2012; 18 (7-8): 806-815

- Essential Regulation of CNS Angiogenesis by the Orphan G Protein-Coupled Receptor GPR124 SCIENCE
  2010; 330 (6006): 985-989

- Two-component protein-engineered physical hydrogels for cell encapsulation PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA
  Foo, C. T., Lee, J. S., Mulyasasmita, W., Parisi-Amon, A., Heilshorn, S. C.
  2009; 106 (52): 22067-22072

- Dynamic, three-dimensional pattern formation within enzyme-responsive hydrogels Advanced Materials
  Straley KS, Heilshorn SC
  2009; 21 (41): 4148-4152

- Independent tuning of multiple biomaterial properties using protein engineering Soft Matter
  Straley KS, Heilshorn SC
  2009; 5: 114-124

- Adaptable Hydrogel Networks with Reversible Linkages for Tissue Engineering ADVANCED MATERIALS
  Wang, H., Heilshorn, S. C.
  2015; 27 (25): 3717-3736

- Matrix interactions modulate neurotrophin-mediated neurite outgrowth and pathfinding NEURAL REGENERATION RESEARCH
  Madl, C. M., Heilshorn, S. C.
  2015; 10 (4): 514-517

- Injectable Hydrogels with In Situ Double Network Formation Enhance Retention of Transplanted Stem Cells ADVANCED FUNCTIONAL MATERIALS
  Cai, L., Dewi, R. E., Heilshorn, S. C.
  2015; 25 (9): 1344-1351

- Protein-engineered hydrogel encapsulation for 3-d culture of murine cochlea. Otology & neurotology
  Chang, D. T., Chai, R., DiMarco, R., Heilshorn, S. C., Cheng, A. G.
  2015; 36 (3): 531-538

- Microfluidic Gradients Reveal Enhanced Neurite Outgrowth but Impaired Guidance within 3D Matrices with High Integrin Ligand Densities SMALL
  2015; 11 (6): 722-730

- Matrix RGD ligand density and LICAM-mediated Schwann cell interactions synergistically enhance neurite outgrowth. Acta biomaterialia
  Romano, N. H., Madl, C. M., Heilshorn, S. C.
Microfluidic analysis of extracellular matrix-bFGF crosstalk on primary human myoblast chemoproliferation, chemokinesis, and chemotaxis. *INTEGRATIVE BIOLOGY*
Ferreira, M. M., Dewi, R. E., Heilshorn, S. C.
2015; 7 (5): 569-579

Multi-Site Functionalization of Protein Scaffolds for Bimetallic Nanoparticle Templating. *ADVANCED FUNCTIONAL MATERIALS*
Huggins, K. N., Schoen, A. P., Arunagirinathan, M. A., Heilshorn, S. C.
2014; 24 (48): 7737-7744

Avidity-controlled hydrogels for injectable co-delivery of induced pluripotent stem cell-derived endothelial cells and growth factors. *Journal of controlled release*
Mulyasasmita, W., Cai, L., Dewi, R. E., Jha, A., Ullmann, S. D., Luong, R. H., Huang, N. F., Heilshorn, S. C.
2014; 191: 71-81

Hybrid Elastin-like Polypeptide-Polyethylene Glycol (ELP-PEG) Hydrogels with Improved Transparency and Independent Control of Matrix Mechanics and Cell Ligand Density. *BIOMACROMOLECULES*
2014; 15 (9): 3421-3428

Mulyasasmita, W., Cai, L., Hori, Y., Heilshorn, S. C.
2014; 20 (15-16): 2102-2114

Rheology and simulation of 2-dimensional clathrin protein network assembly. *Soft matter*
2014; 10 (33): 6219-6227

Small-molecule axon-polarization studies enabled by a shear-free microfluidic gradient generator. *Lab on a chip*
2014; 14 (12): 2047-2056

Designing ECM-mimetic materials using protein engineering. *ACTA BIOMATERIALIA*
Cai, L., Heilshorn, S. C.
2014; 10 (4): 1751-1760

Engineering of three-dimensional microenvironments to promote contractile behavior in primary intestinal organoids. *Integrative biology*
Dimarco, R. L., Su, J., Yan, K. S., Dewi, R., Kuo, C. J., Heilshorn, S. C.
2014; 6 (2): 127-142

Presentation of BMP-2 Mimicking Peptides in 3D Hydrogels Directs Cell Fate Commitment in Osteoblasts and Mesenchymal Stem Cells. *BIOMACROMOLECULES*
Madl, C. M., Mehta, M., Duda, G. N., Heilshorn, S. C., Mooney, D. J.

A microfluidic-based genetic screen to identify microbial virulence factors that inhibit dendritic cell migration. *INTEGRATIVE BIOLOGY*
2014; 6 (4): 438-449

Dual-stage growth factor release within 3D protein-engineered hydrogel niches promotes adipogenesis. *BIOMATERIALS SCIENCE*
Greenwood-Goodwin, M., Teasley, E. S., Heilshorn, S. C.
2014; 2 (11): 1627-1639

One-pot synthesis of elastin-like polypeptide hydrogels with grafted VEGF-mimetic peptides. *BIOMATERIALS SCIENCE*
2014; 2 (5): 757-765

Design of three-dimensional engineered protein hydrogels for tailored control of neurite growth. *ACTA BIOMATERIALIA*
2013; 9 (3): 5590-5599
• Protein-Engineered Injectable Hydrogel to Improve Retention of Transplanted Adipose-Derived Stem Cells. *ADVANCED HEALTHCARE MATERIALS*
  Parisi-Amon, A., Mulyasasmita, W., Chung, C., Heilshorn, S. C.
  2013; 2 (3): 428-432

• Sequence-Specific Crosslinking of Electrospun, Elastin-Like Protein Preserves Bioactivity and Native-Like Mechanics. *ADVANCED HEALTHCARE MATERIALS*
  2013; 2 (1): 114-118

• Chemotaxis of human induced pluripotent stem cell-derived endothelial cells. *AMERICAN JOURNAL OF TRANSLATIONAL RESEARCH*
  Huang, N. F., Dewi, R. E., Okogbaa, J., Lee, J. C., Jalilrufaihah, A., Heilshorn, S. C., Cooke, J. P.
  2013; 5 (5): 510-U96

• Spontaneous cardiomyocyte differentiation of mouse embryoid bodies regulated by hydrogel crosslink density. *BIOMATERNALS SCIENCE*
  Chung, C., Pruitt, B. L., Heilshorn, S. C.
  2013; 1 (10): 1082-1090

• Engineered clathrin nanoreactors provide tunable control over gold nanoparticle synthesis and clustering. *JOURNAL OF MATERIALS CHEMISTRY B*
  Schoen, A. P., Huggins, K. N., Heilshorn, S. C.
  2013; 1 (48): 6662-6669

• Microfluidic devices for quantifying the role of soluble gradients in early angiogenesis. *Mechanical and Chemical Signaling in Angiogenesis*
  edited by Reinhart-King, C. A.
  Heidelberg, Germany, Springer. 2013: 1

• Spontaneous cardiomyocyte differentiation of mouse and embryoid bodies regulated by hydrogel crosslink density. *Biomaterials Science*
  Chung, C., Pruitt, B. L., Heilshorn, S. C.
  2013; 10 (1): 1082-1090

• Dynamic remodelling of disordered protein aggregates is an alternative pathway to achieve robust self-assembly of nanostructures. *SOFT MATTER*
  2013; 9 (38): 9137-9145

• Chemotaxis of human induced pluripotent stem cell-derived endothelial cells. *American journal of translational research*
  Huang, N. F., Dewi, R. E., Okogbaa, J., Lee, J. C., Jalilrufaihah, A., Heilshorn, S. C., Cooke, J. P.
  2013; 5 (5): 510-520

• Tuning colloidal association with specific peptide interactions. *SOFT MATTER*
  Schoen, A. P., Hommersom, B., Heilshorn, S. C., Leunissen, M. E.
  2013; 9 (29): 6781-6785

• Complex chemoattractive and chemorepellent Kit signals revealed by direct imaging of murine mast cells in microfluidic gradient chambers. *INTEGRATIVE BIOLOGY*
  Shamloo, A., Manchandia, M., Ferreira, M., Mani, M., Nguyen, C., Jahn, T., Weinberg, K., Heilshorn, S.
  2013; 5 (8): 1076-1085

• Engineered Protein Templates Synthesize Inorganic Nanomaterials. *CHEMICAL ENGINEERING PROGRESS*
  2012; 108 (12): 47-50

• Tetrakis(hydroxymethyl) Phosphonium Chloride as a Covalent Cross-Linking Agent for Cell Encapsulation within Protein-Based Hydrogels. *BIOMACROMOLECULES*
  Chung, C., Lampe, K. J., Heilshorn, S. C.
  2012; 13 (12): 3912-3916

• Protein-Engineered Biomaterials to Generate Human Skeletal Muscle Mimics. *ADVANCED HEALTHCARE MATERIALS*
  Sengupta, D., Gilbert, P. M., Johnson, K. J., Blau, H. M., Heilshorn, S. C.
  2012; 1 (6): 785-789
• Multifunctional Materials through Modular Protein Engineering  *ADVANCED MATERIALS*
  Dimarco, R. L., Heilshorn, S. C.
  2012; 24 (29): 3923-3940

• Mechanisms of Vascular Endothelial Growth Factor-Induced Pathfinding by Endothelial Sprouts in Biomaterials  *TISSUE ENGINEERING PART A*
  Shamloo, A., Xu, H., Heilshorn, S.
  2012; 18 (3-4): 320-330

• The intestinal stem cell markers Bmi1 and Lgr5 identify two functionally distinct populations  *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA*
  2012; 109 (2): 466-471

• Hydrogel crosslinking density regulates temporal contractility of human embryonic stem cell-derived cardiomyocytes in 3D cultures  *SOFT MATTER*
  Chung, C., Anderson, E., Pera, R. R., Pruitt, B. L., Heilshorn, S. C.
  2012; 8 (39): 10141-10148

• Hydrogels from Protein Engineering  *Biomimetic Approaches for Biomaterials Development*
  Greenwood-Goodwin, M., Heilshorn, S. C.
  edited by Mano, J. F.
  Mannheim, Germany, Wiley-VCH Verlag..2012: 1

• Engineered Protein Biomaterials.  *Biomedical Engineering Handbook*
  Parisi-Amon, A., Heilshorn, S. C.
  edited by Bronzino, J. D., Peterson, D. R., Fisher, J. P.
  Boca Raton, FL, CRC Press.2012: 4th: 1

• Protein-Engineered Hydrogels.  *Biomaterials Surface Science*
  Raphel, J., Parisi-Amon, A. P., Heilshorn, S. C.
  edited by Taubert, A., Mano, J., Rodriguez-Cabello, J. C.
  Mannheim, Germany, Wiley-VCH Verlag..2012: 1

• Photoreactive elastin-like proteins for use as versatile bioactive materials and surface coatings  *JOURNAL OF MATERIALS CHEMISTRY*
  Raphel, J., Parisi-Amon, A., Heilshorn, S. C.
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• Template Engineering Through Epitope Recognition: A Modular, Biomimetic Strategy for Inorganic Nanomaterial Synthesis  *JOURNAL OF THE AMERICAN CHEMICAL SOCIETY*
  2011; 133 (45): 18202-18207

• Molecular-Level Engineering of Protein Physical Hydrogels for Predictive Sol-Gel Phase Behavior  *BIOMACROMOLECULES*
  Mulyasasmita, W., Lee, J. S., Heilshorn, S. C.
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• Protein-engineered biomaterials: Nanoscale mimics of the extracellular matrix  *BIOCHIMICA ET BIOPHYSICA ACTA-GENERAL SUBJECTS*
  Romano, N. H., Sengupta, D., Chung, C., Heilshorn, S. C.
  2011; 1810 (3): 339-349

• Vacuum soft lithography to direct neuronal polarization  *SOFT MATTER*
  2011; 7 (2): 343-347

  Mulyasasmita, W., Heilshorn, S. C.
  edited by Ducheyne, P., Healy, K., Hutmacher, D. W.
  Oxford, UK, Elsevier Science..2011: 1

• High Speed Water Sterilization Using One-Dimensional Nanostructures  *NANO LETTERS*
• Protein-Engineered Biomaterials: Highly Tunable Tissue Engineering Scaffolds  *Tissue Engineering Part B-Reviews*
  Sengupta, D., Heilshorn, S. C.
  2010; 16 (3): 285-293

• Local and Long-Range Reciprocal Regulation of cAMP and cGMP in Axon/Dendrite Formation  *Science*
  Shelly, M., Lim, B. K., Cancedda, L., Heilshorn, S. C., Gao, H., Poo, M.
  2010; 327 (5965): 547-552

• Matrix density mediates polarization and lumen formation of endothelial sprouts in VEGF gradients  *Lab on a Chip*
  Shamloo, A., Heilshorn, S. C.
  2010; 10 (22): 3061-3068

• Protein Engineered Biomaterials. *Protein Engineering.*
  Wong, C. P., Heilshorn, S. C.
  edited by Park, S. J., Cochran, J. R.
  Boca Raton, FL, CRC Press. 2010: 1

• The Interplay between Biomechanical and Biochemical Factors Regulates Lumen Formation and Navigation of Endothelial Cell Sprouts  *12th ASME Summer Bioengineering Conference*
  Shamloo, A., Heilshorn, S. C.
  AMER SOC MECHANICAL ENGINEERS. 2010: 429–430

• Biomaterial Design Strategies for the Treatment of Spinal Cord Injuries  *Journal of Neurotrauma*
  Straley, K. S., Foo, C. W., Heilshorn, S. C.
  2010; 27 (1): 1-19

• Dynamic, 3D-Pattern Formation Within Enzyme-Responsive Hydrogels  *Advanced Materials*
  Straley, K. S., Heilshorn, S. C.
  2009; 21 (41): 4148–?

• Gradient lithography of engineered proteins to fabricate 2D and 3D cell culture micro environments  *Biomedical Microdevices*
  Wang, S., Foo, C. W., Warrier, A., Poo, M., Heilshorn, S. C., Zhang, X.
  2009; 11 (5): 1127-1134

• Formation and properties of magnetic chains for 100nm nanoparticles used in separations of molecules and cells  *7th International Conference on Scientific and Clinical Applications of Magnetic Carriers*
  Wilson, R. J., Hu, W., Fu, C. W., Koh, A. L., Gaster, R. S., Earhart, C. M., Fu, A., Heilshorn, S. C., Sinclair, R., Wang, S. X.
  ELSEVIER SCIENCE BV. 2009: 1452–58

• Designer Protein-Based Scaffolds for Neural Tissue Engineering  *Annual International Conference of the IEEE-Engineering-in-Medicine-and-Biology-Society*
  Straley, K., Heilshorn, S. C.
  IEEE. 2009: 2101–2102

• Independent tuning of multiple biomaterial properties using protein engineering  *Soft Matter*
  Straley, K. S., Heilshorn, S. C.

• Design and adsorption of modular engineered proteins to prepare customized, neuron-compatible coatings.  *Frontiers in neuroengineering*
  Straley, K. S., Heilshorn, S. C.
  2009; 2: 9–?

• Endothelial cell polarization and chemotaxis in a microfluidic device  *Lab on a Chip*
  Shamloo, A., Ma, N., Poo, M., Sohn, L. L., Heilshorn, S. C.
  2008; 8 (8): 1292-1299

• LKB1/STRAD promotes axon initiation during neuronal polarization  *Cell*
  Shelly, M., Cancedda, L., Heilshorn, S., Sumbre, G., Poo, M.
  2007; 129 (3): 565-577
- **Lithographic patterning of photoreactive cell-adhesive proteins**  *Journal of the American Chemical Society*
  2007; 129 (16): 4874-?

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  Heilshorn, S. C., Liu, J. C., Tirrell, D. A.
  2005; 6 (1): 318-323

- **Comparative cell response to artificial extracellular matrix proteins containing the RGD and CS5 cell-binding domains**  *Biomacromolecules*
  Liu, J. C., Heilshorn, S. C., Tirrell, D. A.
  2004; 5 (2): 497-504

- **Endothelial cell adhesion to the fibronectin CS5 domain in artificial extracellular matrix proteins**  *Biomaterials*
  2003; 24 (23): 4245-4252

- **Liquid personal cleansing compositions which contain a complex coacervate for improved sensory perception**  *Assignee: The Procter & Gamble Company.*
  Glenn, R. W., Sine, M. R., Evans, M. D., Carethers, M. E., Heilshorn, S. C.
  2000