

BARRY ANDREW TRIMMER, PhD
Henry Bromfield Pearson Professor of Natural Science

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Primary area of research

Neuromechanics and the control of soft-bodied locomotion. Soft Robotics. Biomorphic devices. Central processing of sensory information by receptors, second messengers and synaptic networks in an insect model system.

Appointments and awards

2012-present	Editor in Chief, <i>Soft Robotics</i> , MaryAnn Liebert Inc. publishers
2012-present	PI and Director of the Tufts IGERT: Soft Material Robotics PhD program
2005-present	Endowed Chair. <i>Henry Bromfield Pearson Professor of Natural Science</i>
Fall 2006	Visiting professor Scuola Superiore Sant'Anna, Pisa, Italy
2006	Founder and Director, Tufts Biomimetics Devices Laboratory
2004-present	Professor, Biology, Arts and Sciences, Tufts University
2003-present	Associate Professor (secondary appointment), Biomedical Engineering, School of Engineering, Tufts University
2002	Nominated for Howard Hughes Medical Institute Professors Award.
1998-present	Secondary appointments in the Departments of Neuroscience, and Pharmacology and Experimental Therapeutics, Tufts University School of Medicine.
1996-2003	Director of the Graduate program in Biology
1996	Associate Professor of Biology (with tenure).
1995 spring	Andrew W. Mellon Foundation Research-Semester Fellowship
1991-1995	Alfred P. Sloan Research Fellow.
1990-1996	Assistant Professor of Biology, Tufts University.

Education

1988-1990	Postdoctoral Research Associate in Neurosciences, University of Oregon, Institute of Neuroscience. <i>Pharmacological analysis of an identified synapse</i> . Research advisor, Dr. Janis C. Weeks.
1987-1988	Postgraduate Research Fellow in Neurobiology, University of California, Berkeley, Department of Entomology. <i>Synaptic transmission in <u>Manduca sexta</u></i> . Research advisor, Dr. Janis C. Weeks.
1985-1986	Research Fellow in Neurobiology. Harvard Medical School, Department of Neurobiology. <i>Neuropeptides in the CNS</i> . Research advisor, Dr. Edward A. Kravitz.
1983-1985	Harkness Fellow, Harvard Medical School. Department of Neurobiology. <i>Localization of octopamine and other neurotransmitters in the lobster nervous system</i> . Research advisor, Dr. Edward A. Kravitz.
1983-1984	Nuffield Foundation Research Fellowship, University of Cambridge, Department of Zoology. <i>Inositol phosphates in cellular signaling</i> . Research advisor, Michael J. Berridge.
1979-1983	Ph.D. Neurobiology: University of Cambridge, England. Research advisor, Professor Sir Michael J. Berridge. Thesis: <i>Serotonin and the control of salivation in <u>Calliphora</u></i>
1976-1979	B.A. Zoology: University of Cambridge, England. Honors 1 st class.

Professional society memberships

Member IEEE, American Association for the Advancement of Science, American Association of University Professors, International Brain Research Organization, International Society for Neuroethology, Society of Integrative and Comparative Biology, Society for Neuroscience.

Review panels and other academic activities

Editor in Chief, “Soft Robotics” published by Mary Ann Liebert Inc. 2012-present. I am the Biological Insights Leader of the Coordination Action for Soft Robotics (part of the European Commission, Future and Emerging Technologies Open Scheme (FP7-ICT-2013-C project # 619319). *Ad hoc* grant reviewer for the National Science Foundation and BBSRC (UK), Grant reviewer for NASA (Early Career Awards, 2014). Reviewer for the Journal of Experimental Biology, Journal of Comparative Physiology, Journal of Neuroscience, American Zoologist, Journal of Insect Physiology, Journal of Neurophysiology, Insect Biochemistry and Molecular Biology, American Journal of Physiology, Trends in Pharmacological Sciences.

Co organizer of the Annual East Coast Nerve Net Conference at the MBL, Woods Hole since 1991.

Judge for the Massachusetts State Science Fair.

Current, pending and recent research funding (current total \$6,173,216, pending Tufts funds \$1,309,796)

Current

1. **National Science Foundation** – Integrative Organismal Systems IOS-1456471 “Neuromechanics of soft-bodied locomotion” PI Trimmer. Period 8/01/15-7/31/18. \$610,000. **Current.**
2. **National Science Foundation** – Integrative Graduate Education and Research Training (DGE-IGERT) 1144591 “Soft Material Robotics”. PI, Trimmer with co-PI David Kaplan (Biomedical Engineering). \$2,709,036. Period 07/01/12-06/30/17. **Current.**
3. **National Science Foundation** – Integrative Organismal Systems IOS-1557672 “Biocomponent devices: developing actuators from insect muscles”. PI Trimmer, co-PI David Kaplan. Period 7/01/16-6/30/19. \$616,724. **Current.**
4. **ARO 67469-EG. Army Research Office** – “Dynamic tuning of instabilities for high power movements in deformable structures” PI Trimmer. Co-PIs Cowan, Shepherd. Total \$1,800,185. Period 5/01/16-4/30/21. **Current.**
5. **Tufts Faculty Research Awards** – “Transcriptome Characterization of Bio-engineered Muscle Constructs”. PI, Trimmer. \$5,000 04/01/2014-03/31/2015. **Current.**
6. **Tufts Collaborates! Award** – “Genomic Analysis of Muscle-Tendon Formation for Tissue Engineering”. PI Trimmer, co-PI Catherine Kuo (Biomedical Engineering). \$20,318, 06/01/14 - 06/30/15. **Current.**

Recently Declined

1. **Google Research Award.** “Soft Robot Control: Hard Problems in Software and Deformable Devices” PI Trimmer. Total Costs \$62,727.
2. **National Science Foundation** – National Robotics Initiative, CSE Directorate, Division of Information and intelligent Systems “NRI: Bio-materials development for soft robots” PI with co-PIs David Kaplan (Biomed. Eng.) and Luis Dorfmann (Civ. & Env. Eng). Direct costs \$474,459, total costs \$728,346. Period 07/01/15-06/30/18. Submitted 01/14/2015.
3. **National Science Foundation** – National Robotics Initiative, CSE Directorate, Division of Information and intelligent Systems “NRI: Softworms: a non-pneumatic platform for soft robot development” PI. Direct costs \$486,182, total cost \$745,961. Period 07/01/15-06/30/18. Submitted 01/14/2015.
4. **National Science Foundation** – Research Traineeship, NSF 15-542 “NRT-IGE: Changing Graduate Education at Tu Institutions” Period 1/01/2016-2019. PI Trimmer, co-PIs: Robert Cook, David Kaplan – Tufts University; Donald Gaver, Anne-Marie Job – Tulane University, Alan Peterfreund, SageFox Consulting Group. **Letter of intent, declined.**

5. **National Science Foundation** – MRI: Acquisition of a High-Resolution Micro-Computed Tomography System for Multidisciplinary STEM Research and Undergraduate Training” Dr. Scott Kirkton as the Principal Investigator. Collaborator with John Rieffel Union College, Submitted 1/2015. **Declined.**
6. **National Science Foundation** – ENGINEERING RESEARCH CENTERS 1606641. “Engineering Research Center for Multi-scale Approach to Brain Systems Science and Technology” PI Kaplan, David Pre-proposal. Fall 2015. **Not Invited**
7. **Samsung. GRO Project Theme and Sub Theme: Soft Robotics.** “Softworms: a non-pneumatic platform for soft robot development” PI, Trimmer, 9/2015-8/2018. \$99,994. **Not funded**

Other recent funding completed

1. **National Science Foundation** – “Neuromechanics of soft-bodied locomotion”. Total \$561,725, direct costs \$376,715; indirect costs \$185,010. PI, Trimmer. Period 3/01/11-2/28/15. IOS- 1050908. **Completed.**
2. **National Science Foundation** – Division of Civil, Mechanical, and Manufacturing Innovation (CCMI), #1100452 Control Systems. “Limit Cycle Control for Soft, Caterpillar-Inspired Robots”. co-PIs Trimmer and Jason Rife (Mech. Eng.). \$187,545, total \$272,990. Period 02/01/12-01/31/15. **Completed.**
3. **DARPA BAA 10-65** – “BioComponent Robot Systems”. Total \$2,299,465. Co-PI with David Kaplan. 02/01/2011-01/31/2014. Army W911NF-11-1-0079. **Completed.**
4. **National Science Foundation** – Major Research Instrumentation (MRI-R²). “Acquisition of a high resolution multi-material printing system.” co-PI with R. Peattie (Biomedical Engineering) and Robert White (Mech. Eng.) \$330,000. Period 01/07/11-06/30/13. DBI-1126382. **Completed.**
5. **National Science Foundation** – Doctoral dissertation improvement grant “Mechanics of Soft-bodied Legged Locomotion: Are Caterpillars Worms with Legs?” IOS-0909953. Total \$14,987. Period 06/01/09-05/30/11. PI, with Co-PIs Huai-ti Lin and Luis Dorfmann. **Completed.**
6. **National Science Foundation** – “Neuromechanics of soft-bodied locomotion”. Total \$473,320, direct costs \$303,410, indirect costs \$169,910. Period 9/01/07 - 3/31/11 IOS-0718537. **Completed**
7. **Defense Advanced Research Projects Agency (DARPA)** – “Chemical Robots: morphing soft material robots for covert access”. Contract 08-C-0012. Total \$3,292,749. 02/14/08 – 02/13/10 Co PI David Kaplan (*Tufts University School of Engineering*). **Completed**
8. **National Science Foundation** – “Multidisciplinary Research Opportunity for Women (MRO-W) program” Total \$15,500. Period 09/01/08-08/15/09. Co-PI with Soha Hassoun (*Tufts University School of Engineering*). **Completed.**
9. **W.M Keck Foundation Science and Engineering Program** – “Biomimetic Technologies for Soft-bodied robots”. \$730,000. Co-PI with Dr. David Kaplan (Biomed. Eng.). 2006-2008. **Completed.**

Recent seminars and Presentations (selected)

Climbing in complex environments: gait adaptation by a soft-bodied invertebrate. Barry Trimmer and Cinzia Metallo. International Congress of Neuroethology (ICN), March 30– April 2016, Montevideo, Uruguay.

Poster Presentation

Adaptive Control of Caterpillar Proleg Grip. Ritwika Mukherjee, Samuel C. Vaughan and Barry A. Trimmer. International Congress of Neuroethology (ICN), March 30– April 2016, Montevideo, Uruguay. **Poster Presentation**

Neuromechanics of Softbodied Locomotion. NSF 5th annual Winter Workshop on Neuromechanics and Dynamics of Locomotion, Tulane, LA, Jan. 21-22, 2016, **Invited talk**

Adaptive control of caterpillar proleg grip. R. Mukherjee and B Trimmer. Society for Integrative and Comparative Biology (SICB) Annual Meeting. Portland OR, Jan. 3-7 2016. **Poster Presentation**

Novel Approach to Characterizing Mechanosensory Feedback in Soft-Bodied Animals Using Manduca sexta. Scibelli, A. E; Trimmer, B.A. Society for Integrative and Comparative Biology (SICB) Annual Meeting. Portland OR, Jan. 3-7 2016. **Poster Presentation**

Animal model systems for soft robots. Wyss Symposium "Bioinspired Robotics: Softer, Smarter, Safer" Harvard. June 29, 2015. **Invited talk**

Soft Wear: Neuromechanics for Soft Animals and Robots. Purdue University, School of Mechanical Engineering. October 29, 2015. **Invited talk**

Climbing in Complex Environments: Robots und Raupen. Adaptive Movement in Animals and Machines, June 21, June 25, 2015 MIT, Cambridge MA. **Invited talk**

Model-free control framework for multi-limb soft material robots. V. Vikas, P. Grover and B. Trimmer. Adaptive Movement in Animals and Machines, June 21, June 25, 2015 MIT, Cambridge MA. **Poster Presentation.**

Using Social Media to Crowdsource Control Strategies for Soft-bodied Robots. Whitney Crooks, Chris Rogers, and Barry Trimmer. Adaptive Movement in Animals and Machines, June 21, June 25, 2015 MIT, Cambridge MA. **Poster Presentation.**

Structural Vibration for Robotic Communication and Sensing on One-Dimensional Structures. Maxwell Hill, Jerry Mekdara, Barry Trimmer and Robert White. Adaptive Movement in Animals and Machines, June 21, June 25, 2015 MIT, Cambridge MA. **Poster Presentation.**

How will soft technology make better robots? RoboSoft Plenary Meeting, Livorno, Italy April 15-16, 2015. **Invited talk.**

Soft Approaches to Hard Problems: Movement in Deformable Animals and Robots. Shanghai Lecture Series. February 3, 2015. **Invited teleconference talk.**

Soft Approaches to Hard Problems: The Neuromechanics of Highly Deformable Animals and Robots. Cornell University, College of Engineering, November 25th 2014. **Invited seminar.**

Soft Robotics: Challenges and Opportunities. Workshop on Distributed Sensing, Actuation, and Control for Bioinspired Soft Robotics. September 10-12, 2014. University of Maryland workshop. **Invited talk.**

Softworm robots: 3D-printed crawling machines. Advances on Soft Robotics, IEEE Robotics: Science and Systems Conference Workshop. University of California Berkeley July 12-18, 2014. **Invited seminar.**

Locomotion in Caterpillars and Soft Robots: Neuromechanics and Distributed Control. Hokkaido University Sapporo, Japan. March 18-23. 2014, **Invited seminar**

Soft Robotics – Origins and Futures. Teleconference presentation to the Naval Surface Warfare Center, Disruptive Technologies Lab, July 8, 2014. **Invited talk.**

Bone-free: Soft Mechanics for Adaptive Locomotion. Society for Integrative and Comparative Biology, Annual Meeting, 2014. January 3-7, Austin Texas, **Invited speaker** for the symposium on Terrestrial Locomotion

The Neuromechanics of Soft-bodied Locomotion in Caterpillars and Robots Georgia Institute of Technology, School of Physics, November 11-12 2013 **Invited seminar.**

Conformable passive grasping by caterpillars and soft robots. Workshop on Soft Technologies for Wearable Robots. IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2013), November 2-8, Big Sight, Tokyo, Japan.

Moving Softly: Locomotion Strategies for Deformable Animals and Robots. Adaptive Movements in Animals and Machines (AMAM2013). March 11-14, 2013. Darmstadt, Germany. Keynote Talk

Soft Living Machines: controlling movement in highly deformable structures. 2013 International Workshop on Soft Robotics and Morphological Computation. July 14-19, 2013. Centro Stefano Franscini, Ascona Switzerland. Keynote Talk

High Degrees of Freedom: Hard Problems for Soft Animals and Robots. BBN Technologies, Cambridge. MA. Feb. 29, 2012. Invited Seminar.

Soft-bodied locomotion: animals, robots and morphological computation. ETH Robotics Summer School on Soft Robotics 2012, June 18-22, 2012, Zurich, Switzerland. Invited lecture series.

Caterpillars and Soft Material Robots. IEEE International Conference on Biomedical Robotics and Biomechanics (BioRob 2012). June 24-27, 2012, Rome, Italy. Workshop on Biologically Inspired Approaches to Multi-Modal Robotic Locomotion. Invited speaker.

Towards a biomorphic soft robot: design constraints and solutions. IEEE International Conference on Biomedical Robotics and Biomechanics. June 24-27, 2012 Rome, Italy. Presenter.

Soft animals and robots: controls, structures and adaptable locomotion. The 3rd EMBODYi OCTOPUS-EVRYON-WSK-TNg Summer School. June 24, 2012. , Rome, Italy. Invited Speaker

Biosynthetic Robots: growing machines from living cells. The "Living Machines" conference organized by the Convergent Science Network, Barcelona, Spain. July 10-12th 2012. Plenary Lecture.

Biocomponent Robots: DARPA Maximum mobility and Manipulation (M3) Meeting July 17-18, 2012. Co-presenter with D. Kaplan

Living Machines: Soft Animals, Soft Robots and Biohybrids. The ShanghAI Lecture series Nov. 1, 2012. Webcast Internationally. Guest lecture.

Biocomponent Robots. DARPA M3 Review meeting. Destin Fl., January 24-25, 2012. Project leader

Lessons from Life: Novel locomotion strategies for soft animals and robots. The 15th International Conference on Advanced Robotics (ICAR). Workshop on Soft Robotics, Tallinn, Estonia June 20-23, 2011. Invited speaker.

Soft-bodied locomotion: animals, robots and morphological computation. Northwestern University, McCormick School of Engineering, February 25, 2011. Invited speaker.

The environmental skeleton: Tension-based locomotion in a soft-bodied climbing insect. International Congress of Neurothology, Salamanca, Spain, August 2-7, 2010, selected participant seminar.

Soft-bodied locomotion: animals, robots and morphological computation Case Western Reserve University Biology Department, April 15, 2010. Invited speaker.

Soft bodies and weak minds: what caterpillars can teach us about neuromechanics Washington and Lee University Computer Science and Biology Programs. March 22, 2010. Invited speaker.

Department service

Chair, new faculty search committee (optogenetics), Fall 2014-Spring 2015. Chair of the Animal Physiologist Faculty Search committee (2010-11). Director, Tufts Biomimetic Devices Laboratory (2006-). Department representative to the Tenure and Promotion subcommittee (promotion of Prof. Romero). Search committee for an appointment in molecular biology (2004-2005). Search committee for a new endowed chair appointment in molecular evolution (2003-2006). Biology graduate program director (1996-2003) and Chair of the Graduate Admissions Committee. Administrator for the Biology Department Home Page (1995- 2001). Biology Department Computer Advisory Committee (1993- present). Kenneth Roeder Memorial Lecture organizing committee (1992-present). Biopsychology major committee (1991- present).

University service

Science and Engineering Building Planning committee (Neuroscience Team Leader) 2014-15. University Council on Graduate Education (Chair, 2007-2010). Faculty Research Support Facilities Advisory Committee (co-Chair 2002-2004). Computer Facilities and Usage Committee. Graduate school Programs and Policies committee. Task force on intellectual life: Beyond the classroom subcommittee. Higher education initiative "Excellence in Scholarship and Research" focus group member.

Teaching

Biomimetics: Software and hardware models for understanding animal behavior (Biology 193-07). A new advanced level seminar for graduate students and approved undergraduates offered Spring 2007, 2012.

Neurobiology (Biology 134). A comprehensive overview of the primary areas in basic neuroscience for upper-division undergraduate and graduate credit. 40 lectures in the Spring semester, 1991 to present (except during my sabbaticals in 1997 and 2007).

Experiments in Physiology (Biology 49). I direct this 11 week lab course, which is taught by three faculty members and a teaching assistant. I also teach one of the 4-week units. Two 3 hr labs and a 1 hr recitation weekly in the fall semester 1992 to 1997 and 2000-present.

Physiology of Animal Locomotion (Biology 246). A new graduate level seminar course taught by four faculty members. 4x3 hr meetings for each faculty (Spring 2016).

Advanced Neurobiology Special Topics A seminar course for graduate students specializing in Neuroscience. Topics are explored using recent primary literature (Biology 293, Fall 1993, Spring 2002).

Design of Medical Devices (Electrical Engineering 100). I give 1-2 lectures in this course each year.

Advanced Molecular and Cellular Pharmacology (Pharmacology 231, Sackler School). I give two (2 hr) lectures in this course including a laboratory demonstration.

Undergraduate Independent Research. I have sponsored and advised 90 individual student projects for credit in my laboratory since 1991.

Postdoctoral scholars sponsored (dates, current positions and affiliations)

Dr. Sanjive Qazi (1991-2000). Biology Department, Gustavus Adolphus College, St Peter MN

Dr. Jim Belanger (1998-2000). Associate Professor, Biology Dept. West Virginia University

Dr. Margaret Bloch-Qazi (1999-2000). Associate Professor, Gustavus Adolphus College, St Peter MN.

Dr. David Fickbohm (1995-1997). Life science faculty, Santa Monica College, CA.

Dr. Jonathan Issberner (August 2000-2005). Research associate University of St. Andrews.

Dr. John Rieffel (February 2008-2009). Assistant Professor in Computer Science, Union College, NY

Dr. William Woods (November 2004-present). Research Assistant Professor (2009) in my lab

Dr. Ethan Golden (July 2008-2012) Postdoctoral associate in my lab

Dr. Vishesh Vikas (July 2012-present)

Dr. Takuya Umedachi (Dec 2012- present) A Fellow of the Japan Society for the Promotion of Science.

Dr. Cinzia Metallo (October 2013-present).

Thesis advisor for Ph.D. and MS candidates

Dr. Alice Wang (1992- defended December 1998, PhD.)

Dr. Ricardo Zayas (1997- 2002) Assistant Professor, San Diego State University

Dr. Anke Vermehren (1998-2003) Postdoctoral associate, Cell and Developmental Biology, OHSU

Ms. Jessica Bosc (Spring 2002- defended Feb. 2004, research MS)

Mr. Russell Benuck (Fall 2003- defended Feb. 2004, research Masters in Biomedical Engineering)

Mr Daniel Hake (Masters in Mechanical Engineering, Graduated 2006)

Ms. Nina Mallozzi (MS. defended May 2007)

Ms. Meghan Kate (MS. Biomedical Engineering, defended May 2009)

Dr. Michael Simon (2004-2010 defended June 2010, PhD.)

Dr. Huai-Ti, Lin (2006-2011, defended January, 2011, PhD)

Dr. Linnea van Griethuijsen (2006-2012, defended March 2012, PhD)

Dr. Cinzia Metallo (defended September 2013, PhD)

Current Graduate Students

Mr. Michael Doire (MS program, BME, matriculated 2010)

Anthony Scibelli

Jerry Mekdera

Cassandra Donatelli

Ritwika Mukherjee

Jacqueline Clark

Naya McCartney

Thesis committee member for 11 additional graduate students

Additional graduate student laboratory rotations

Fallon Schuler (2011), Emily Pitcairn (2011-13), Claire Parker (2012), Maria Lobikin (2009), Jamison Brewer (2006, Sackler School Dept. Neurobiology), Amy Yu (2005), Ramya Iyer (2000), Michael Foy (2003, Sackler School Dept. Pharmacology), Nicole Cyr (2003), Meta Mason (2003), Tatyana Fedina (2002), Alex Ciota (2001), Haihua Zhang (2000), Chris Cratsley (1996).

Public outreach and education

Two presentations to the Jewish Community Day School, Waltham MA, February 6th, 2015 *Caterpillars and Soft Robots: What Animals Teach us About Building Machines*

Host for day-long department visits by seniors at the Minuteman Technical Academy (1997-1999).

National Public Radio interview “All things considered” June 29, 2001.

BBC Radio 4 “The Material World” discussion July 2001.

Interviewed for “Wild Moments” a syndicated nature program.

Article featured in BBC Wildlife Magazine, Fall 2001.

I regularly do presentations (“Metamorphosis, the big change”) at local primary schools using *Manduca* as a demonstration of some astounding processes in biology.

PUBLICATIONS

Manuscripts submitted and in preparation

1. Hill, L.M., Mekdara, J., Trimmer, B., and White, R. (2015). Structural Vibration for Robotic Communication and Sensing on One-Dimensional Structures. In Adaptive Motion in Animals and Machines (AMAM), June 22-25, 2015, **submitted**. (MIT, Cambridge, MA).
2. Vaughan, S., Lin, H.-t. and **Trimmer, B. A.** Soft-bodied climbing: robust, tension-based omni-directional locomotion. *Journal of Experimental Biology* - **submitted** in revision.
3. Takuya Umedachi¹, Takeshi Kano, Akio Ishiguro, and Barry A. Trimmer. Gait control in a soft robot by sensing interactions with the environment using self-deformation (2106) Royal Society Open Science. Submitted RSOS-160021.
4. Takuya Umedachi and Barry A. Trimmer. Autonomous Decentralized Control for Soft-bodied Caterpillar-like Modular Robot Exploiting Large and Continuum Deformation. IROS 2016 Submitted

Published original research and reviews

1. Vikas, V., Cohen, E, Grassi, R., Sozer, C. and **Trimmer, B.A.** (2016) Design and locomotion control of a motor-tendon driven soft robot. *IEEE Transactions on Robotics*, *in press*.
2. Umedachi, T., Vikas, V. and **Trimmer B.A.** (2016) Softworms: The Design and Control of Non-pneumatic, 3D-Printed, Deformable Robots" *Bioinspiration & Biomimetics* 11.(2).10.1088/1748-3190/11/2/025001
3. Vikas V., Grover P. and **Trimmer, B.A.** (2015). Model-free control of multi-limb soft robots. In: *International Conference on Intelligent Robots and Systems*, (Hamburg, Germany: IEEE/RSJ). arXiv:1509.05937.
4. Cohen, E., Vikas, V., **Trimmer, B.A.**, and McCarthy, S. (2015). Design methodologies for soft-material robots through additive manufacturing; from prototyping to locomotion. In: *Proceedings of the ASME 2015 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference IDETC/CIE 2015*, (Boston, US).
5. **Trimmer, B.A.** (2015). Soft-bodied terrestrial invertebrates. In: *Living Machines: A Handbook of Biomimetic and Biohybrid Systems*, T. Prescott, P. Verschure and N. Lepora, eds. (Oxford University Press), **in press**.
6. Ahamed, T., Rubin, M.B., **Trimmer, B.A.**, and L., Dorfmann. (2016). The time-dependent behavior of passive skeletal muscle. *Continuum Mech. Thermodyn.* 28:561–577. DOI 10.1007/s00161-015-0464-z.
7. Metallo, C., and **Trimmer, B.A.** (2015). Silk coating as a novel delivery system and reversible adhesive for stiffening and shaping flexible electrodes. *Journal of Biological Methods* 2.10.14440/jbm.2015.41.

8. Metallo, C., and **Trimmer, B.A.** (2015) Orientation-dependent changes in single motor neuron activity during adaptive soft-bodied locomotion. *Brain, Behavior and Evolution*. 85:47-62. DOI: 10.1159/000369372.
9. Schuldt, D., Rife, J., and **Trimmer, B.A.** (2015). A template for robust soft-body crawling with reflex-triggered gripping. *Bioinspiration & Biomimetics* 10.1088/1748-3190/10/1/016018.
10. Baryshyan, A.L., L. Domigan, B. Hunt, **B.A. Trimmer**, and D. Kaplan, (2014) Self-assembled insect muscle bioactuators with long term function under a range of environmental conditions. *RSC Advances*: 4, 39962-39968. DOI: 10.1039/C4RA08438A.
11. **Trimmer B.A.** and Lin, H-t, (2014) Bone-free: Soft Mechanics for Adaptive Locomotion. *Integrative and Comparative Biology*. DOI: 10.1093/icb/icu076.
12. Umedachi, T., and **Trimmer, B.A.** (2014). Design of a 3D-printed soft robot with posture and steering control. IEEE International Conference on Robotics and Automation (ICRA) pp. 2874-2879. 10.1109/ICRA.2014.6907272.
13. van Griethuijsen, L.I. and **Trimmer, B. A.** (2014) Locomotion in caterpillars. *Biological Reviews*. 89(3): p. 656-670. DOI:10.1111/brv.12073.
14. Umedachi, T, Vikas, V. and **Trimmer, B.A.** (2013) Highly Deformable 3-D Printed Soft Robot Generating Inching and Crawling Locomotion with Variable Friction Legs. *Proceedings of IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS 2013)*, Tokyo, Japan, Nov 3-7. p 4590-4595. DOI: 10.1109/IROS.2013.6697016.
15. Lin, H-t, Leisk, G. and **Trimmer, B.A.** (2013) Soft Robots in Space: A Perspective for Soft Robotics. *Acta Futura*. 6:69-79. DOI: 10.2420/AF06.2013.69.
16. **Trimmer, B.** (2013) Soft robots. *Current Biology*: 23 (15), R639-R641.
17. Kim, S., Laschi, C. **Trimmer B.A.** (2013) Soft Robotics: A New Perspective in Robot Evolution. *Trends in Biotechnology* **31**: 287-294.
18. Griethuijsen, L. I. v., Banks, K.M. and **Trimmer, B. A.** (2013) Spatial accuracy of a rapid defense behavior in caterpillars. *Journal of Experimental Biology*. **216**(3):379-387. DOI: 10.1242/jeb.070896
19. Rieffel, J., Knox, D., Smith, S. and **Trimmer, B.A.** (2013) Growing and evolving soft robots. *Artificial Life*. 1-20. DOI: 10.1162/ARTL_a_00101.
20. Lin, H-t and **Trimmer, B.A.** (2012) A new bi-axial cantilever beam design for biomechanics force measurements. *Journal of Biomechanics*. **45**(13) 2310-4. <http://dx.doi.org/10.1016/j.jbiomech.2012.06.005>.
21. **Trimmer, B. A.**, Huai-Ti, L., Baryshyan, A., Leisk, G. G. and Kaplan, D. L. (2012). Towards a biomorphic soft robot: Design constraints and solutions. In *Biomedical Robotics and Biomechatronics (BioRob), 2012 4th IEEE RAS & EMBS International Conference on*, pp. 599-605.
22. Baryshyan, A., Woods, W. **Trimmer, B.A.** and Kaplan, D.L. (2012) Isolation and maintenance-free culture of contractile myotubes from *Manduca sexta* embryos. *PLoS One*. **7**(2): e31598. doi:10.1371/journal.pone.0031598.
23. Paetsch, C., **Trimmer, B. A.** and Dorfmann A. (2012) A constitutive model for active-passive transition of muscle fibers *International Journal of Non-Linear Mechanics*, **47**, 377-387.
24. Lin, H-t, Leisk, G. and **Trimmer, B.A.** (2011) GoQBot: A caterpillar-inspired soft-bodied rolling robot. *Bioinspiration & Biomimetics* **6**(2), doi: 10.1088/1748-3182/6/2/026007.
25. Lin, H.-T., Slate, D., Paetsch, C., Dorfmann, L. and **Trimmer, B.** (2011). Scaling of caterpillar body properties and its biomechanical implications on the use of hydrostatic skeletons. *Journal of Experimental Biology* **214**, 1194-1204. doi:10.1242/jeb.051029.
26. Saunders, F., **Trimmer, B.A.** and Rife, R. (2011) Modeling locomotion of a soft bodied arthropod using inverse-dynamics. *Bioinspiration & Biomimetics* **6** (1). doi: 10.1088/1748-3182/6/1/016001.
27. Metallo, C., White, R. D., **Trimmer, B.A.** (2011) Flexible parylene-based microelectrode arrays for high resolution EMG recordings in freely moving small animals. *Journal of Neuroscience Methods*. **195**(2), 176-184. doi:10.1016/j.jneumeth.2010.12.005.

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Other Publications

Books Chapters and Thesis

1. Buschmann, T and **Trimmer, B.A.** (2015) Bio-inspired robot locomotion. To appear in: *The Neurobiology of Motor Control: Fundamental Concepts and New Directions*. Editors: Scott L. Hooper and Ansgar Büschges. Wiley. **In press**.
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Editorials and Discussion Moderation

1. 3D Printing Soft Materials: What Is Possible? (2015) Barry Trimmer, Jennifer A. Lewis, Robert F. Shepherd, Hod Lipson *Soft Robotics*, Vol 2(1): pp 3-6.
2. Trimmer, B.A. (2015) Soft Robots and Society *Soft Robotics*. Vol, 2(1): pp. 1-2.
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Recent abstracts and presentations

- Baryshyan, A., **Trimmer, B.A.** and Kaplan, D. (2013) Functional three-dimensional insect muscle tissue for bioactuation applications. Biomedical Engineering Society (BMES) Annual Meeting, September 25-28, 2013 in Seattle, Washington.
- Domigan, L., **Trimmer, B.A.** and Kaplan, D. (2013) Metabolic strategies for long-term survival of in vitro cultured *Manduca sexta* muscle. Biomedical Engineering Society (BMES) Annual Meeting, September 25-28, 2013 in Seattle, Washington.
- Griethuijzen, L. van, and **Trimmer, B.A.** (2012) Spatial accuracy of a rapid defense behavior in caterpillars. *Tenth International Congress of Neuroethology*. University of Maryland, College Park, MD USA. August 5-10, 2012.
- Metallo, C. and **Trimmer, B.A.** (2012) Flexible Parylene-Based Multi-Electrode Arrays for Surface EMG Recordings From Facial Muscles. *34th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC'12)*, San Diego, California, USA, August 28 - September 1, 2012.
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- Woods Jr., W. A., Schuler, F. R., Yee, A. L. and **Trimmer, B. A.** (2012) Optimizing work and power production of a *Manduca sexta* larval locomotory muscle. *The Society for Integrative and Comparative Biology (SICB) Annual Meeting* January 3-7, 2012. Charleston, SC, USA.
- Lin, H.-T. and **Trimmer, B.A.** (2011) Decoding static-locomotion: ground reaction forces in caterpillar crawling and a simple mechanistic model of the environmental skeleton. *Annual meeting of the Society for Integrative and Comparative Biology (SICB)*. Salt Lake City, UT January 3-7.
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- Simon, M.A. and **Trimmer, B.A.** (2009) “Visualizing internal movements during soft-bodied crawling using x-ray micro-videography”. *Society for Integrative and Comparative Biology Annual Meeting*. January 3-7. Boston, Massachusetts. Poster.
- Meghan Kate, Greg Bettencourt, James Marquis, Aaron Gerratt, Peter Fallon, Brian Kierstead, Robert White and Barry Trimmer, (2008) "SoftBot : A soft-material flexible robot based on caterpillar biomechanics" in *Adaptive Movement in Animals and Machines, AMAM 2008*, Cleveland, OH, June 1-6.
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- Kate. M.H. and **Trimmer, B.A.** (2008) “SoftBot: A soft-material flexible robot based on caterpillar biomechanics and neuromechanical control”. *East Coast Nerve Net, Woods Hole, MA*. April 4-6.
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- Lin, Huai-Ti., Griethuijsen, L. van., Bettencourt, G. and **Trimmer, B.A.** (2007) “Soft-bodied locomotion: caterpillar neuromechanics and a new class of biomimetic robots”. *East Coast Nerve Net, Woods Hole, MA*. April 2-4.
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