Josh C Bongard

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Google Scholar. **9368** citations. H-index: **45**.

Summary Curriculum Vitae

Research Statement

There are two main thrusts in my research group: evolutionary robotics and machine science.

In **evolutionary robotics**, we take a holistic approach to robotics. We teach an AI to design robots "from the ground up" to best be able to perform some desired task. The AI does so by determining where to put motors, sensors, what shape the robot should have, what materials it should constructed from, and how it should be controlled by a neural network. Only this last aspect of a robot's design is covered by traditional AI approaches. Most recently, we have adapted this method to create the world's first computer-designed organisms (the "xenobots"): living robots made from biological tissues, rather than technological components.

In **machine science**, we attempt to automate all aspects of the scientific method. This process usually involves five steps. **1.** A "scientist AI" generates hypotheses about how some system works (e.g. how cells communicate to stabilize after surprise). **2.** An "engineer AI" then dreams up how best to poke the system of interest, or build some interesting version of that system, to test that hypothesis (e.g. a mm-sized robot built from frog tissue). **3.** A "robot scientist" then carries out that intervention, or builds that system variant. **4.** The robot's success or failure is fed back to the scientist AI, leading it to revise its hypothesis. **5.** This process is repeated until the AIs and robot scientist make a new discovery. Often, this discovery is different or beyond what human scientists may have been capable of imagining.

Appointments

2015– Cyril G. Veinott Green and Gold Professor, Department of Computer Science, College of Engineering & Mathematical Sciences, University of Vermont

2015–2019 Director, Vermont Advanced Computing Core, UVM's high performance computing facility.

2014– *Secondary appointment in the School of Engineering, UVM*

2013– *Secondary appointment in the Neuroscience Graduate Program, UVM*

2006– Director, Morphology, Evolution & Cognition Laboratory

2003–2006 **Postdoctoral Associate**, Cornell University
Advisor: Hod Lipson, Director of the Creative Machines Laboratory

Education

1999–2003 **Ph.D.**, Department of Informatics, University of Zurich, Switzerland
Incremental Approaches to the Combined Evolution of a Robot's Body and Brain.
Advisor: Rolf Pfeifer, Director of the Zurich Artificial Intelligence Laboratory

1998–1999 **M.S.**, Evolutionary & Adaptive Systems, University of Sussex, UK

1993–1997 **B.Sc.**, Honors Computer Science, McMaster University, Canada (graduated *Summa Cum Laude*)

BOOKS

1. Pfeifer, R. and J. Bongard (2006)
How the Body Shapes the Way We Think: A New View of Intelligence,
Boston, MA: MIT Press. (Translated into Chinese, Japanese, Arabic and an E-book)

SELECTED PUBLICATIONS

1. S Kriegman, D Blackiston, M Levin, J Bongard (2021)
Kinematic self-replication in reconfigurable organisms.
Proceedings of the National Academy of Sciences, 118(49): e2112672118.

2. D Blackiston, E Lederer, S Kriegman, S Garnier, J Bongard, M Levin (2021)
A cellular platform for the development of synthetic living machines.
Science Robotics, 6(52).

3. JC Bongard & M Levin (2021)
Living things are not (20th century) machines.
Frontiers in Ecology and Evolution, https://doi.org/10.3389/fevo.2021.650726

4. S Kriegman, D Blackiston, M Levin, J Bongard. (2020).
A scalable pipeline for the design of reconfigurable organisms.
Proceedings of the National Academy of Sciences, 117(4): 1853-1859.

5. I Rahwan, M Cebrian, N Obradovich, J Bongard, J-F Bonnefon, C Breazeal, JW Crandall, NA Christakis, ID Couzin, MO Jackson, NR Jennings, E Kamar, IM Kloumann, H Larochelle, D Lazer, R McElreath, A Mislove, DC Parkes, A Pentland, ME Roberts, A Shariff, JB Tenenbaum & M Wellman (2019).
Machine behavior.
Nature, 568: 477–486

6. Bongard, J. C. (2011)
Morphological change in machines accelerates the evolution of robust behavior.
Proceedings of the National Academy of Sciences, 108(4): 1234-1239.

7. Bongard, J. and H. Lipson (2007)
Automated reverse engineering of nonlinear dynamical systems.
Proceedings of the National Academy of Sciences, 104(24): 9943-9948.

8. Bongard, J., V. Zykov and H. Lipson (2006)
Resilient machines through continuous self-modeling.
Science, 314: 1118-1121.

SELECTED MEDIA COVERAGE

Dec, 2021 **Stephen Colbert**
CNN, BBC, CNBC, Science Friday, Forbes, NPR, New Scientist, The Times, Bloomberg, & 100s more.

Jan, 2020 **CNN**

Nov, 2006 "Injured Robot Learns to Limp" *Nature News*
"New Robot Shrugs Off Injury" *Science News*
"Robotic Recovery" *MIT Technology Review*
"Self-Aware Robots" *Discovery Channel*

SELECTED AWARDS

2021 The National Academy of Sciences' **Cozzarelli Prize**. (Announcement video.)

2020 Xenobots nominated for The Design Museum's Beazley Design of the Year
PNAS paper reporting xenobots in Altmetric's Top 100 for 2020.

2014 National STEM Innovation Award (awarded by the Concept Schools)

2010 Presidential Early Career Award for Scientists and Engineers (**PECASE**). [Photo with Obama]
NSF CAREER award.

2007 One of *MIT Technology Review*'s TR35: Top 35 Young Innovators Under 35
Microsoft New Faculty Fellowship