

Artemy Kolchinsky

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CONTACT	E-mail: artemyk@gmail.com Web: https://artemyk.github.io	Google Scholar: link GitHub: @artemyk
EDUCATION	Indiana University (Bloomington, IN, USA), 2015 Ph.D. in Informatics (focus in Complex Systems), Minor in Cognitive Science Thesis: “Measuring Scales: Integration and Modularity in Complex Systems” Committee: Luis M. Rocha (chair), Yong-Yeol Ahn, Randall Beer, Alessandro Flammini, Olaf Sporns New York University (New York, NY, USA), 2004 B.A. Magna Cum Laude, Individualized Study (concentration in Complex Systems)	
ACADEMIC POSITIONS	Universitat Pompeu Fabra (Barcelona, Spain), June 2023- Marie Curie postdoctoral fellow University of Tokyo (Tokyo, Japan), Jan 2022-May 2023 Project researcher at the Universal Biology Institute Santa Fe Institute (Santa Fe, NM, USA), Dec 2015-Dec 2021 Postdoctoral fellow with postdoctoral advisor David H. Wolpert Instituto Gulbenkian de Ciência (Oeiras, Portugal), 2009-2010 and Summer 2008/2011/2012 Visiting researcher at FLAD Computational Biology Collaboratorium Indiana University (Bloomington, IN, USA), Sep 2011-May 2015 Research assistant with Ph.D. advisor Luis M. Rocha	
INDUSTRY	LinkedIn Corporation (Mountain View, CA, USA), Summer 2014 Data science internship. Supervisor: Mathieu Bastian	
PUBLICATIONS	A. Kolchinsky , “Thermodynamic dissipation does not bound replicator growth and decay rates”, <i>The Journal of Chemical Physics</i> , 2024. (2024 JCP Emerging Investigators Special Collection) pdf link R. Solé, C. P. Kempes, B. Corominas-Murtra, M. De Domenico, A. Kolchinsky , M. Lachmann, E. Libby, S. Saavedra, E., D. Wolpert, “Fundamental constraints to the logic of living systems”, <i>Royal Society Interface</i> , in press. preprint P.M. Riechers, C. Gupta, A. Kolchinsky , M. Gu, “Thermodynamically ideal quantum state inputs to any device”, <i>PRX Quantum</i> , 2024. pdf link A. Kolchinsky , “Partial information decomposition: redundancy as information bottleneck”, <i>Entropy</i> , 2024. pdf link J. Piñero, R. Solé, A. Kolchinsky , “Optimization of nonequilibrium free energy harvesting illustrated on bacteriorhodopsin”, <i>Physical Review Research</i> , 2024. pdf link A. Kolchinsky , N. Ohga, S. Ito, “Thermodynamic bound on spectral perturbations, with applications to oscillations and relaxation dynamics”, <i>Physical Review Research</i> , 2024. pdf link D.R. Sowinski, J. Carroll-Nellenback, R.N. Markwick, J. Piñero, M. Gleiser, A. Kolchinsky , G. Ghoshal, A. Frank, “Semantic Information in a model of resource gathering agents”, <i>PRX Life</i> , 2023. pdf link A. Kolchinsky , “Generalized Zurek’s bound on the cost of an individual classical or quantum computation”, <i>Physical Review E</i> , 2023. pdf link M. Aguilera and A. Kolchinsky , “Quantifying higher-order entropy production in organized nonequilibrium states”, <i>Proceedings of the ALIFE 2023</i> , 2023. pdf link	

N. Ohga, S. Ito, **A. Kolchinsky**, “Thermodynamic bound on the asymmetry of cross-correlations”, *Physical Review Letters*, 2023. (Editors’ Suggestion; Featured in *Physics*) [pdf link](#)

K. Yoshimura, **A. Kolchinsky**, A. Dechant, S. Ito, “Housekeeping and excess entropy production for general nonlinear dynamics”, *Physical Review Research*, 2023. [pdf link](#)

F.C. Sheldon, **A. Kolchinsky**, F. Caravelli, “Computational capacity of LRC, memristive, and hybrid reservoirs”, *Physical Review E*, 2022. [pdf link](#)

A. Kolchinsky, “A Novel Approach to the Partial Information Decomposition”, *Entropy*, 2022. [pdf code link](#)

A. Kolchinsky and D.H. Wolpert, “Dependence of integrated, instantaneous, and fluctuating entropy production on the initial state in quantum and classical processes”, *Physical Review E*, 2021. [pdf link](#)

A. Kolchinsky and D.H. Wolpert, “Work, entropy production, and thermodynamics of information under protocol constraints”, *Physical Review X*, 2021. [pdf link](#)

A. Kolchinsky and D.H. Wolpert, “Entropy production given constraints on the energy functions”, *Physical Review E*, 2021. [pdf link](#)

A. Kolchinsky and D.H. Wolpert, “Thermodynamic costs of Turing Machines”, *Physical Review Research*, 2020. [pdf link](#)

D.H. Wolpert and **A. Kolchinsky**, “The thermodynamics of computing with circuits”, *New Journal of Physics*, 2020. [pdf link](#)

A. Kolchinsky and B. Corominas-Murtra, “Decomposing information into copying versus transformation”, *Royal Society Interface*, 2020. [pdf link](#)

A.M. Saxe, Y. Bansal, J. Dapello, M. Advani, **A. Kolchinsky**, B.D. Tracey, D.D. Cox, “On the information bottleneck theory of deep learning”, *Journal of Statistical Mechanics*, 2019. [pdf code link](#)

A. Kolchinsky, B.D. Tracey, D.H. Wolpert, “Nonlinear information bottleneck”, *Entropy*, 2019. (*Entropy* 2021 Best Paper Award) [pdf link](#)

A. Berdahl, C. Brelsford, C. De Bacco, M. Dumas, V. Ferdinand, J.A. Grochow, L. Hébert-Dufresne, Y. Kallus, C.P. Kempes, **A. Kolchinsky**, D. B. Larremore, E. Libby, E.A. Power, C.A. Stern, B.D. Tracey, “Dynamics of beneficial epidemics”, *Scientific Reports*, 2019. [pdf link](#)

E.A. Hobson, V. Ferdinand, **A. Kolchinsky**, J. Garland, “Rethinking animal social complexity measures with the help of complex systems concepts”, *Animal Behaviour*, 2019. [pdf link](#)

A. Kolchinsky, B.D. Tracey, S. Van Kuyk, “Caveats for information bottleneck in deterministic scenarios”, *International Conf on Learning Representations (ICLR)*, 2019. [pdf code link](#)

D.H. Wolpert, **A. Kolchinsky**, J.A. Owen, “A space–time tradeoff for implementing a function with master equation dynamics”, *Nature Communications*, 2019. [pdf link](#)

A. Avena-Koenigsberger, X. Yan, **A. Kolchinsky**, M. van den Heuvel, P. Hagmann, O. Sporns, “A spectrum of routing strategies for brain networks”, *PLoS Computational Biology*, 2019. [pdf link](#)

J.A. Owen, **A. Kolchinsky**, D.H. Wolpert, “Number of hidden states needed to physically implement a given conditional distribution”, *New Journal of Physics*, 2019. (*correction*) [pdf link](#)

A. Kolchinsky and D.H. Wolpert, “Semantic information, autonomous agency, and nonequilibrium statistical physics”, *Royal Society Interface Focus*, 2018. [pdf code link](#)

A.M. Saxe, Y. Bansal, J. Dapello, M. Advani, **A. Kolchinsky**, B.D. Tracey, D.D. Cox, “On the information bottleneck theory of deep learning”, *International Conf on Learning Representations (ICLR)*, 2018. [pdf code link](#)

A. Kolchinsky, N. Dhande, K. Park, Y.Y. Ahn, “The Minor Fall, the Major Lift: Inferring emotional valence of musical chords through lyrics”, *Royal Society Open Science*, 2017. [pdf data code link](#)

A. Kolchinsky, D.H. Wolpert, “Dependence of dissipation on the initial distribution over states”, *Journal of Statistical Mechanics*, 2017. [pdf link](#)

A. Kolchinsky, B.D. Tracey, “Estimating mixture entropy with pairwise distances”, *Entropy*, 2017. (*correction*) [pdf code link](#)

A. Kolchinsky, A.J. Gates, L.M. Rocha, “Modularity and the spread of perturbations in complex dynamical systems,” *Physical Review E*, 2015. [pdf code link](#)

A. Kolchinsky, A. Lourenço, H. Wu, L. Li, L.M. Rocha, “Extraction of pharmacokinetic evidence of drug-drug interactions from the literature,” *PLOS One*, 2015. [pdf link](#)

A. Kolchinsky, M.P. van den Heuvel, A. Griffa, P. Hagmann, L.M. Rocha, O. Sporns, J. Goñi, “Multi-scale integration and predictability in resting state brain activity,” *Frontiers in Neuroinformatics*, 2014. [pdf link](#)

A. Rossi, F.J. Parada, **A. Kolchinsky**, A. Puce, “Neural correlates of apparent motion perception of impoverished facial stimuli I: A comparison of ERP and ERSP activity,” *NeuroImage*, 2014. [pdf link](#)

A. Kolchinsky, A. Lourenço, L. Li, L.M. Rocha, “Evaluation of linear classifiers on articles containing pharmacokinetic evidence of drug-drug interactions,” *Proc Pacific Symposium on Biocomputing*, 2013. [pdf link](#)

A. Kolchinsky and L.M. Rocha, “Prediction and modularity in dynamical systems,” *Proc of European Conf. on the Synthesis and Simulation of Living Systems (ECAL)*, 2011. [pdf link](#)

A. Kolchinsky, A. Abi-Haidar, J. Kaur, A.A. Hamed, L.M. Rocha, “Classification of protein-protein interaction full-text documents using text and citation network features,” *IEEE/ACM Transactions on Computational Biology and Bioinformatics*, 2010. [pdf link](#)

POPULAR SCIENCE

A. Kolchinsky, “The cost of sending a bit across a living cell”, *Physics Magazine*, 2023. [link](#)

PREPRINTS

K. R. Thomsen, **A. Kolchinsky**, S. Rasmussen, “Metabolism, information, and viability in a simulated physically-plausible protocell”, arXiv:2405.04654, 2024. [arxiv](#)

A. Kolchinsky, “Thermodynamics of Darwinian evolution in molecular replicators”, arXiv:2112.02809, 2024. [arxiv](#)

R. Nagayama, K. Yoshimura, **A. Kolchinsky**, S. Ito, “Geometric thermodynamics of reaction-diffusion systems: Thermodynamic trade-off relations and optimal transport for pattern formation”, arXiv:2311.16569, 2023. [arxiv](#)

A. Kolchinsky, A. Dechant, K. Yoshimura, S. Ito, “Information geometry of excess and housekeeping entropy production”, arXiv:2206.14599, 2022. [arxiv](#)

C. Gokler, **A. Kolchinsky**, Z. Liu, I. Marvian, P. Shor, O. Shtanko, K. Thompson, D. Wolpert, S. Lloyd, “When is a bit worth much more than $kT \ln 2$?”, arXiv:1705.09598, 2017. [arxiv](#)

A. Kolchinsky, I. Marvian, C. Gokler, Z. Liu, P. Shor, O. Shtanko, K. Thompson, D. Wolpert, S. Lloyd, “Maximizing free energy gain”, arXiv:1705.00041, 2017. [arxiv](#)

INVITED TALKS

2/2024 - *Seminar at Barcelona Collaboratorium for Modelling and Predictive Biology*, Barcelona, Spain
“Stochastic thermodynamics: promises and challenges for studying living systems”

11/2023 - *Mini-workshop: Non-equilibrium thermodynamics and biology*, Biofiska Institute, Bilbao, Spain
“Stochastic thermodynamics: promises and limitations for studying living matter”

11/2023 - *Seminar*, Basque Center for Applied Mathematics, Bilbao, Spain
“Nonequilibrium thermodynamics, cross-correlations, and the isoperimetric inequality”

7/2023 - *Information Engines at the Frontiers of Nanoscale Thermodynamics*, Telluride, CO, USA
“Information geometry for nonequilibrium processes”

6/2023 - *Mathematics, Physics & Machine Learning Webinar*, Instituto Superior Técnico, Lisbon, Portugal
“Information geometry for nonequilibrium processes” (virtual)

6/2023 - *Conference on Decomposing Multivariate Information in Complex Systems*, Max Planck Institute for the Physics of Complex Systems, Dresden, Germany
“A Novel Approach to the Partial Information Decomposition”

9/2022 - *Seminar at Dutch Institute of Emergent Phenomena*, University of Amsterdam, Netherlands
“Information geometry of fluxes and forces in nonequilibrium thermodynamics” (virtual)

8/2022 - *Seminar*, Earth-Life Science Institute (ELSI), Tokyo, Japan

“Thermodynamics of Darwinian evolution in molecular replicators”

6/2022 - *Evolution of complexity from the statistical physics perspective*, Yerevan Physics Institute, Armenia

“Thermodynamics of Darwinian evolution” (virtual)

6/2022 - *Yagami Statistical Physics Seminar*, Keio University, Japan

“Thermodynamics under protocol constraints” (virtual)

5/2022 - *Workshop on Stochastic Thermodynamics III*, University of Tokyo, Japan

“The algorithmic cost of a single classical or quantum computation” (virtual)

4/2022 - *Cross Labs Workshop: Is AI Extending the Mind?*, Cross Labs, Japan

“Autonomous agents and semantic information” (virtual)

2/2022 - *Physics Department Colloquium Series*, University of Rochester, NY, USA

“A thermodynamic threshold for Darwinian evolution” (virtual)

12/2021 - *Universal Biology Institute Seminar Series*, University of Tokyo, Japan

“A thermodynamic threshold for Darwinian evolution” (virtual)

02/2021 - *Origins of Life: The Possible and the Actual* workshop, Santa Fe Institute, NM, USA

“Fundamental thermodynamic constraints and trade-offs in origin of life”

7/2020 - *ICTP Seminar Series*, Abdus Salam International Center for Theoretical Physics, Trieste, Italy

“Bounds on entropy production and thermodynamics of information under protocol constraints” (virtual)

2/2020 - *AI Seminar Series*, Information Sciences Institute, Los Angeles, CA, USA

“Machine Learning through the information bottleneck”

7/2019 - *ISTI Seminar Series*, Los Alamos National Lab, Los Alamos, NM, USA

“Machine Learning through the information bottleneck”

6/2018 - *Connectomics Lecture Series*, Universidad Diego Portales, Santiago, Chile

“Machine learning, deep neural networks, and the brain”

4/2018 - *Meeting of the Society for the Neural Control of Movement*, Santa Fe, NM, USA

“Machine learning, deep neural networks, and the brain”

4/2018 - *SITE Santa Fe* (contemporary art museum), Santa Fe, NM, USA

“Life, entropy, and the 2nd law of thermodynamics”

11/2017 - Seoul National University, South Korea

“Science at the Santa Fe Institute” (w/ V. Ferdinand)

8/2017 - *Thermodynamics & Computation: Towards a New Synthesis*, Santa Fe Institute, NM, USA

“Statistical physics of Turing Machines”

10/2016 - *Statistical Physics, Information Processing and Biology*, Santa Fe Institute, NM, USA

“Dependence of dissipation on the initial distribution”

2/2016 - Information Sciences Institute, Los Angeles, CA, USA

“Multi-scale integration & modularity in complex systems”

AWARDS & FELLOWSHIPS

2022 - Marie Curie Individual Fellowship (HORIZON-MSCA-2021-PF-01)

“NETOLIFE: Nonequilibrium thermodynamics of the origin of life”

2012 - 2013 - Lilly Graduate Fellowship, Biocomplexity Institute, Indiana University, Bloomington, IN

2007 - 2009 - Eli Lilly Fellowship, Indiana University, Bloomington, IN,

2004 - Dean’s List Gallatin School, New York University, NY

GRANTS

2023 - John Templeton Foundation (62828), \$947,926, Co-PI

“Goal-directed behavior and the origin of life”

2022 - John Templeton Foundation (62417), \$627,227, Co-PI

“Information architectures that enable life: the emergence of meaning”

2019 - Foundational Questions Institute (FQXi-RFP-IPW-1912), \$118,100, Co-Investigator (PI: David Wolpert)
 “The role of constraints in the thermodynamics of intelligence”

2016 - Foundational Questions Institute (FQXi-RFP-1622), \$128,319, Co-Investigator (PI: David Wolpert)
 “Observers as self-maintaining non-equilibrium systems”

2016 - NSF INSPIRE (CHE-1648973), \$999,947, co-author (PI: David Wolpert)
 “Tradeoffs in the Thermodynamics of Computation: A New Paradigm for Biological Information-Processing”

2016 - NSF (1620462), \$770,000, co-author (PI: David Wolpert)
 “Information Networks and the Evolution of Social Organizations”

TEACHING

Online courses

2018 - “Fundamentals of machine learning” (w/ B.D. Tracey), Complexity Explorer from the Santa Fe Institute
 Designed and delivered a 12-part online course on basics of machine learning [\[link\]](#)

Workshops, lectures, and tutorials

6/2019 - Santa Fe Institute Complex Systems Summer School, NM, USA

Two lecture series on machine learning and its research frontiers

3/2019 - Santa Fe Institute, NM, USA

Tutorial on “Machine learning with TensorFlow”

6/2017, 6/2018 - Santa Fe Institute, NM, USA

Tutorial on introduction to programming and data analysis in Python (w/ V. Ferdinand)

11/2017 - Seoul National University, Seoul, South Korea

Week-long workshop on “Thermodynamics, evolution, and inference through the lens of information theory”
 (w/ V. Ferdinand)

11/2017 - ACTioN/Trustee Meeting, Santa Fe Institute, NM, USA

Lecture on “Machine learning: A guide for the perplexed” (w/ B. D. Tracey)

5/2010 - Instituto Gulbenkian de Ciência, Oeiras, Portugal

Assisted with week-long “Bayesian brain” educational module

Teaching Assistant at Indiana University, Bloomington, IN

Spring 2014 - “I400 Large-scale Social Phenomena” [\[link\]](#)

Spring 2011 - “I201 Math and logic foundations of Informatics”

Fall 2010 - “I485 Biologically Inspired Computing” [\[link\]](#)

Developed and implemented a 5-part computational lab series

Fall 2008-Spring 2009 - “I210 Information Infrastructure” (Python programming)

ADVISING

Nicolas Freitas, Santa Fe Institute REU Program, Santa Fe, NM, June-August, 2018

Project: “Scaling of information in biochemical systems”

Francis Cavanna, Santa Fe Institute REU Program, Santa Fe, NM, June-August, 2017

Project: “Investigating the relationship between criticality and Landauer costs using the Ising model”

ACADEMIC SERVICE

Guest editor: *Entropy* special issue on “Thermodynamics and Information Theory of Living Systems” [link](#)

Reviewer

Physics: *New J of Physics*, *PRL*, *PRR*, *PRE*, *Frontiers in Physics*, *J of Physics A*, *Physica A*

Biology: *J R Soc Proc B*, *PLoS Comp Bio*, *Theory in the Biosciences*

Information theory and machine learning: *Entropy*, *ICLR*, *IEEE Trans on Pattern Analysis and Machine Intelligence*, *Kybernetika*, *Applied Sciences*

Other

2008-2013 - Started and ran a weekly discussion group on complexity, dynamical systems, and embodiment in cognitive science, Indiana University, Bloomington, IN [link](#)

SKILLS

Programming: Python, MATLAB, C, C++, R, Java

machine learning with TensorFlow, web programming, databases/SQL, scalable computing

Languages: Fluency: English, Russian, Spanish / Basic: Portuguese