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Joshua T. Vogelstein

Demographic & Personal Information

Current Appointments

- 09/19 – now **Joint Appointment**, Department of Biostatistics, Johns Hopkins University (JHU).
- 08/15 – now **Joint Appointment**, Department of Applied Mathematics and Statistics, (JHU).
- 08/14 – now **Assistant Professor**, Department of Biomedical Engineering, (JHU).
- 08/14 – now **Core Faculty**, Institute for Computational Medicine (ICM), (JHU).
- 08/14 – now **Core Faculty**, Center for Imaging Science (CIS), (JHU).
- 08/14 – now **Joint Appointment**, Department of Neuroscience, (JHU).
- 08/14 – now **Joint Appointment**, Department of Computer Science, (JHU).
- 08/14 – now **Assistant Research Faculty**, Human Language Technology Center of Excellence, (JHU).
- 10/12 – now **Affiliated Faculty**, Institute for Data Intensive Engineering and Sciences, (JHU).

Education & Training

- 2003 – 2009 **Ph.D in Neuroscience**, Johns Hopkins School of Medicine,
Advisor: Eric Young,
Thesis: OOPSI: a family of optical spike inference algorithms for inferring neural connectivity from population calcium imaging .
- 2009 – 2009 **M.S. in Applied Mathematics & Statistics**, Johns Hopkins University.
- 1998 – 2002 **B.A. in Biomedical Engineering**, Washington University, St. Louis.

Academic Experience

- 08/18 – now **Director of Biomedical Data Science Focus Area**, Department of Biomedical Engineering, Johns Hopkins University.
- 05/16 – now **Visiting Scientist**, Howard Hughes Medical Institute, Janelia Research Campus.
- 10/12 – 08/14 **Endeavor Scientist**, Child Mind Institute.
- 08/12 – 08/14 **Affiliated Faculty**, Kenan Institute for Ethics.
Duke University
- 08/12 – 08/14 **Adjunct Faculty**, Department of Computer Science, Johns Hopkins University.
- 12/09 – 01/11 **Post-Doctoral Fellow**, Department of Applied Mathematics and Statistics, Supervised by Carey E. Priebe, Johns Hopkins University.
Research Statistics of populations of networks.
- 06/01 – 09/01 **Research Assistant**, Prof. Randy O'Reilly, Dept. of Psychology.
University of Colorado
- 06/00 – 09/00 **Clinical Engineer**, Johns Hopkins Hospital.
- 06/99 – 08/99 **Research Assistant under Dr. Jeffrey Williams**, Dept. of Neurosurgery, Johns Hopkins Hospital.
- 06/98 – 08/98 **Research Assistant under Professor Kathy Cho**, Dept. of Pathology, Johns Hopkins School of Medicine.

Publications

Published Peer-Reviewed Research Articles

Note: CV author in bold; Trainees in italics,

(55 papers; top 10 cited 3,128 times; H-index 30) as of 2020/01/06

- [55] *Shangsi Wang, Jesús Arroyo, Joshua T Vogelstein, and Carey E Priebe*. “Joint Embedding of Graphs”. In: *Transactions on Pattern Analysis and Machine Intelligence* in press (Oct. 2019). URL: <http://arxiv.org/abs/1703.03862>.
- [54] *Youjin Lee, Cencheng Shen, Carey E Priebe, and Joshua T Vogelstein*. “Network dependence testing via diffusion maps and distance-based correlations”. In: *Biometrika* (Sept. 2019). ISSN: 0006-3444. DOI: [10.1093/biomet/asz045](https://doi.org/10.1093/biomet/asz045). arXiv: [1703.10136](https://arxiv.org/abs/1703.10136). URL: <https://doi.org/10.1093/biomet/asz045>.
- [53] *Jaewon Chung, Benjamin D. Pedigo, Eric W. Bridgeford, Bijan K. Varjavand, and Joshua T. Vogelstein*. “GraSPy: Graph Statistics in Python”. In: *Journal of Machine Learning Research* 20.158 (Apr. 2019), pp. 1–7. eprint: <https://arxiv.org/abs/1904.05329>. URL: <http://jmlr.org/papers/v20/19-490.html>.
- [52] **Joshua T. Vogelstein**, *Eric W. Bridgeford, Benjamin D. Pedigo, Jaewon Chung, Keith Levin, Brett Mensh, and Carey E. Priebe*. “Connectal Coding: Discovering the Structures Linking Cognitive Phenotypes to Individual Histories”. In: *Current Opinion in Neurobiology* 55 (Apr. 2019), pp. 199–212. ISSN: 18736882. DOI: [10.1016/j.conb.2019.04.005](https://doi.org/10.1016/j.conb.2019.04.005). URL: <https://doi.org/10.1016/j.conb.2019.04.005>.
- [51] *Jake J. Son, Jon C. Clucas, Curt White, Anirudh Krishnakumar, Joshua T. Vogelstein, Michael P. Milham, and Arno Klein*. “Thermal sensors improve wrist-worn position tracking”. In: *npj digital medicine* 2.1 (Feb. 2019). ISSN: 2398-6352. DOI: [10.1038/s41746-019-0092-2](https://doi.org/10.1038/s41746-019-0092-2). URL: <https://doi.org/10.1038/s41746-019-0092-2>.
- [50] *Carey E. Priebe, Youngser Park, Joshua T. Vogelstein, John M. Conroy, Vince Lyzinski, Minh Tang, Avanti Athreya, Joshua Cape, and Eric Bridgeford*. “On a two-truths phenomenon in spectral graph clustering”. In: *Proceedings of the National Academy of Sciences of the United States of America* 116.13 (Feb. 2019), pp. 5995–6000. ISSN: 10916490. DOI: [10.1073/pnas.1814462116](https://doi.org/10.1073/pnas.1814462116). arXiv: [1808.07801](https://arxiv.org/abs/1808.07801). URL: <https://www.pnas.org/content/early/2019/03/07/1814462116.short>.
- [49] **Joshua T. Vogelstein**, *Eric W. Bridgeford, Qing Wang, Carey E. Priebe, Mauro Maggioni, and Cencheng Shen*. “Discovering and deciphering relationships across disparate data modalities”. In: *eLife* 8 (Jan. 2019). ISSN: 2050084X. DOI: [10.7554/eLife.41690](https://doi.org/10.7554/eLife.41690). arXiv: [1609.05148](https://arxiv.org/abs/1609.05148). URL: <https://elifesciences.org/articles/41690>.
- [48] *Runze Tang, Michael Ketcha, Alexandra Badea, Evan D Calabrese, Daniel S Margulies, Joshua T Vogelstein, Carey E Priebe, and Daniel L Sussman*. “Connectome Smoothing via Low-rank Approximations”. In: *Transactions in Medical Imaging* (Dec. 2018). URL: <https://ieeexplore.ieee.org/document/8570772>.
- [47] *Cencheng Shen, Carey E Priebe, and Joshua T Vogelstein*. “From Distance Correlation to Multiscale Graph Correlation”. In: *Journal of the American Statistical Association* (Oct. 2018). URL: <https://www.tandfonline.com/doi/full/10.1080/01621459.2018.1543125>.
- [46] **Joshua T. Vogelstein**, *Eric Perlman, Benjamin Falk, Alex Baden, William Gray Roncal, Vikram Chandrashekhar, Forrest Collman, Sharmishta Seshamani, Jesse L. Patsolic, Kunal Lillaney, Michael Kazhdan, Robert Hider, Derek Pryor, Jordan Matelsky, Timothy Gion, Priya Manavalan, Brock Wester, Mark Chevillet, Eric T. Trautman, Khaled Khairy, Eric Bridgeford, Dean M. Kleissas, Daniel J. Tward, Ailey K. Crow, Brian Hsueh, Matthew A. Wright, Michael I. Miller, Stephen J. Smith, R. Jacob Vogelstein, Karl Deisseroth, and Randal Burns*. “A Community-Developed Open-Source Computational Ecosystem for Big Neuro Data”. In: *Nature Methods* 15.11 (Oct. 2018), pp. 846–847. ISSN: 15487105. DOI: [10.1038/s41592-018-0181-1](https://doi.org/10.1038/s41592-018-0181-1). arXiv: [1804.02835](https://arxiv.org/abs/1804.02835). URL: <https://www.nature.com/articles/s41592-018-0181-1>.

- [45] Avanti Athreya, Donniell E. Fishkind, Minh Tang, Carey E. Priebe, Youngser Park, **Joshua T. Vogelstein**, Keith Levin, Vince Lyzinski, Yichen Qin, and Daniel L. Sussman. “Statistical Inference on Random Dot Product Graphs: a Survey”. In: *Journal of Machine Learning Research* 18 (May 2018), pp. 1–92. ISSN: 15337928. arXiv: [1709.05454](https://arxiv.org/abs/1709.05454). URL: <http://jmlr.org/papers/v18/17-448.html>.
- [44] Joshua D. Cohen, Lu Li, Yuxuan Wang, Christopher Thoburn, Bahman Afsari, Ludmila Danilova, Christopher Douville, Ammar A. Javed, Fay Wong, Austin Mattox, Ralph H. Hruban, Christopher L. Wolfgang, Michael G. Goggins, Marco Dal Molin, Tian Li Wang, Richard Roden, Alison P. Klein, Janine Ptak, Lisa Dobbyn, Joy Schaefer, Natalie Silliman, Maria Popoli, **Joshua T. Vogelstein**, James D. Browne, Robert E. Schoen, Randall E. Brand, Jeanne Tie, Peter Gibbs, Hui Li Wong, Aaron S. Mansfield, Jin Jen, Samir M. Hanash, Massimo Falconi, Peter J. Allen, Shibin Zhou, Chetan Bettegowda, Luis A. Diaz, Cristian Tomasetti, Kenneth W. Kinzler, Bert Vogelstein, Anne Marie Lennon, and Nickolas Papadopoulos. “Detection and localization of surgically resectable cancers with a multi-analyte blood test”. In: *Science* 359.6378 (Feb. 2018), pp. 926–930. ISSN: 10959203. DOI: [10.1126/science.aar3247](https://doi.org/10.1126/science.aar3247). URL: <https://doi.org/10.1126/science.aar3247>.
- [43] Daniele Durante, David B. Dunson, and **Joshua T. Vogelstein**. “Rejoinder: Nonparametric Bayes Modeling of Populations of Networks”. In: *Journal of the American Statistical Association* 112 (Oct. 2017). ISSN: 0162-1459. DOI: [10.1080/01621459.2017.1395643](https://doi.org/10.1080/01621459.2017.1395643). URL: <https://doi.org/10.1080/01621459.2017.1395643>.
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- [41] Shaojie Chen, Kai Liu, Yuguang Yang, Yuting Xu, Seonjoo Lee, Martin Lindquist, Brian S. Caffo, and **Joshua T. Vogelstein**. “An M-estimator for reduced-rank system identification”. In: *Pattern Recognition Letters* 86 (Jan. 2017), pp. 76–81. ISSN: 0167-8655. DOI: [10.1016/J.PATREC.2016.12.012](https://doi.org/10.1016/J.PATREC.2016.12.012). URL: <https://www.sciencedirect.com/science/article/pii/S0167865516303671>.
- [40] Anish K. Simhal, Cecilia Aguerreberere, Forrest Collman, **Joshua T. Vogelstein**, Kristina D. Micheva, Richard J. Weinberg, Stephen J. Smith, and Guillermo Sapiro. “Probabilistic fluorescence-based synapse detection”. In: *PLoS Computational Biology* 13.4 (2017). DOI: [10.1371/journal.pcbi.1005493](https://doi.org/10.1371/journal.pcbi.1005493). URL: <https://doi.org/10.1371/journal.pcbi.1005493>.
- [39] Da Zheng, Disa Mhembere, Vince Lyzinski, **Joshua T. Vogelstein**, Carey E. Priebe, and Randal Burns. “Semi-external memory sparse matrix multiplication for billion-node graphs”. In: *IEEE Transactions on Parallel and Distributed Systems* 28.5 (2017), pp. 1470–1483. ISSN: 10459219. DOI: [10.1109/TPDS.2016.2618791](https://doi.org/10.1109/TPDS.2016.2618791). arXiv: [1602.02864](https://arxiv.org/abs/1602.02864). URL: <https://ieeexplore.ieee.org/abstract/document/7593270>.
- [38] Cencheng Shen, **Joshua T. Vogelstein**, and Carey E. Priebe. “Manifold matching using shortest-path distance and joint neighborhood selection”. In: *Pattern Recognition Letters* 92 (2017), pp. 41–48. ISSN: 01678655. DOI: [10.1016/j.patrec.2017.04.005](https://doi.org/10.1016/j.patrec.2017.04.005). arXiv: [1412.4098](https://arxiv.org/abs/1412.4098). URL: <http://www.sciencedirect.com/science/article/pii/S016786551730106X>.
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- [36] Daniele Durante, David B. Dunson, and **Joshua T. Vogelstein**. “Nonparametric Bayes Modeling of Populations of Networks”. In: *Journal of the American Statistical Association* 112.520 (2017), pp. 1516–1530. ISSN: 1537274X. DOI: [10.1080/01621459.2016.1219260](https://doi.org/10.1080/01621459.2016.1219260). arXiv: [1406.7851](https://arxiv.org/abs/1406.7851). URL: <https://doi.org/10.1080/01621459.2016.1219260>.

- [35] Qing Wang, Ming Zhang, Tyler Tomita, **Joshua T. Vogelstein**, Shibin Zhou, Nickolas Papadopoulos, Kenneth W. Kinzler, and Bert Vogelstein. “Selected reaction monitoring approach for validating peptide biomarkers”. In: *Proceedings of the National Academy of Sciences of the United States of America* 114.51 (2017), pp. 13519–13524. ISSN: 10916490. DOI: [10.1073/pnas.1712731114](https://doi.org/10.1073/pnas.1712731114). URL: <http://www.pnas.org/content/114/51/13519.short>.
- [34] David Grant Colburn Hildebrand, Marcelo Cicconet, Russel Miguel Torres, Woohyuk Choi, Tran Minh Quan, Jungmin Moon, Arthur Willis Wetzel, Andrew Scott Champion, Brett Jesse Graham, Owen Randlett, George Scott Plummer, Ruben Portugues, Isaac Henry Bianco, Stephan Saalfeld, *Alexander David Baden*, *Kunal Lillaney*, Randal Burns, **Joshua Tzvi Vogelstein**, Alexander Franz Schier, Wei Chung Allen Lee, Won Ki Jeong, Jeff William Lichtman, and Florian Engert. “Whole-brain serial-section electron microscopy in larval zebrafish”. In: *Nature* 545.7654 (2017), pp. 345–349. ISSN: 14764687. DOI: [10.1038/nature22356](https://doi.org/10.1038/nature22356). URL: <https://doi.org/10.1038/nature22356>.
- [33] Danai Koutra, Neil Shah, **Joshua T. Vogelstein**, Brian Gallagher, and Christos Faloutsos. “DeltaCon: Principled Massive-Graph Similarity Function with Attribution”. In: *ACM Transactions on Knowledge Discovery from Data* 10.3 (Feb. 2016). ISSN: 1556-4681. DOI: [10.1145/2824443](https://doi.org/10.1145/2824443). URL: <http://doi.acm.org/10.1145/2824443>.
- [32] Vince Lyzinski, Donniell E. Fishkind, Marcelo Fiori, **Joshua T. Vogelstein**, Carey E. Priebe, and Guillermo Sapiro. “Graph Matching: Relax at Your Own Risk”. In: *IEEE Transactions on Pattern Analysis and Machine Intelligence* 38.1 (Jan. 2016), pp. 60–73. ISSN: 01628828. DOI: [10.1109/TPAMI.2015.2424894](https://doi.org/10.1109/TPAMI.2015.2424894). arXiv: [1405.3133](https://arxiv.org/abs/1405.3133). URL: <http://doi.org/10.1109/TPAMI.2015.2424894>.
- [31] Eva L. Dyer, *William Gray Roncal*, Hugo L. Fernandes, Doga Gürsoy, Vincent De Andrade, Rafael Vescovi, Kamel Fezzaa, Xianghui Xiao, **Joshua T. Vogelstein**, Chris Jacobsen, Konrad P. Körding, and Narayanan Kasthuri. “Quantifying Mesoscale Neuroanatomy Using X-Ray Microtomography”. In: *eNeuro* 4 (2016). ISSN: 2373-2822. DOI: [10.1523/ENEURO.0195-17.2017](https://doi.org/10.1523/ENEURO.0195-17.2017). eprint: [1604.03629](https://doi.org/10.1523/ENEURO.0195-17.2017). URL: <https://doi.org/10.1523/ENEURO.0195-17.2017>.
- [30] Raag D. Airan, **Joshua T. Vogelstein**, Jay J. Pillai, Brian Caffo, James J. Pekar, and Haris I. Sair. “Factors affecting characterization and localization of interindividual differences in functional connectivity using MRI”. In: *Human Brain Mapping* 37.5 (2016), pp. 1986–1997. ISSN: 10970193. DOI: [10.1002/hbm.23150](https://doi.org/10.1002/hbm.23150). URL: <http://dx.doi.org/10.1002/hbm.23150>.
- [29] Li Chen, Cencheng Shen, **Joshua T. Vogelstein**, and Carey E. Priebe. “Robust Vertex Classification”. In: *IEEE Transactions on Pattern Analysis and Machine Intelligence* 38.3 (2016), pp. 578–590. ISSN: 01628828. DOI: [10.1109/TPAMI.2015.2456913](https://doi.org/10.1109/TPAMI.2015.2456913). URL: <http://dx.doi.org/10.1109/TPAMI.2015.2456913>.
- [28] Carey E. Priebe, Daniel L. Sussman, Minh Tang, and **Joshua T. Vogelstein**. “Statistical Inference on Errorfully Observed Graphs”. In: *Journal of Computational and Graphical Statistics* 24.4 (Oct. 2015), pp. 930–953. ISSN: 15372715. DOI: [10.1080/10618600.2014.951049](https://doi.org/10.1080/10618600.2014.951049). arXiv: [1211.3601](https://arxiv.org/abs/1211.3601). URL: <https://doi.org/10.1080/10618600.2014.951049>.
- [27] Kristen M. Harris, Josef Spacek, Maria Elizabeth Bell, Patrick H. Parker, Laurence F. Lindsey, Alexander D. Baden, **Joshua T. Vogelstein**, and Randal Burns. “A resource from 3D electron microscopy of hippocampal neuropil for user training and tool development”. In: *Scientific Data* 2 (2015). ISSN: 20524463. DOI: [10.1038/sdata.2015.46](https://doi.org/10.1038/sdata.2015.46). URL: <https://doi.org/10.1038/sdata.2015.46>.
- [26] Li Chen, **Joshua T. Vogelstein**, Vince Lyzinski, and Carey E. Priebe. “A Joint Graph Inference Case Study: the C.elegans Chemical and Electrical Connectomes”. In: *Worm* 5 (2015). ISSN: 2162-4054. DOI: [10.1080/21624054.2016.1142041](https://doi.org/10.1080/21624054.2016.1142041). eprint: [1507.08376](https://arxiv.org/abs/1507.08376). URL: <http://arxiv.org/abs/1507.08376>.
- [25] *William R. Gray Roncal*, Dean M. Kleissas, **Joshua T. Vogelstein**, *Priya Manavalan*, *Kunal Lillaney*, Michael Pekala, Randal Burns, R. Jacob Vogelstein, Carey E. Priebe, Mark A. Chevillet, and Gregory D. Hager. “An automated images-to-graphs framework for high resolution connectomics”. In: *Frontiers in Neuroinformatics* 9 (2015). ISSN: 1662-5196. DOI: [10.3389/fninf.2015.00020](https://doi.org/10.3389/fninf.2015.00020). URL: <http://journal.frontiersin.org/article/10.3389/fninf.2015.00020>.

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- [14] **Joshua T. Vogelstein**, William Gray Roncal, R. Jacob Vogelstein, and Carey E. Priebe. “Graph classification using signal-subgraphs: Applications in statistical connectomics”. In: *IEEE Transactions on Pattern Analysis and Machine Intelligence* 35.7 (2013), pp. 1539–1551. ISSN: 01628828. DOI: [10.1109/TPAMI.2012.235](https://doi.org/10.1109/TPAMI.2012.235). arXiv: [1108.1427](https://arxiv.org/abs/1108.1427). URL: <https://doi.org/10.1109/TPAMI.2012.235>.

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- [6] *Gregory Kiar, Eric Bridgeford, Will Gray Roncal, (CoRR), Vikram Chandrashekhar, Disa Mhembere, Sephira Ryman, Xi-Nian Zuo, Daniel S Marguiles, R Cameron Craddock, Carey E Priebe, Rex Jung, Vince Calhoun, Brian Caffo, Randal Burns, Michael P Milham, and Joshua Vogelstein.* “A High-Throughput Pipeline Identifies Robust Connectomes But Troublesome Variability”. In: *bioRxiv* (Apr. 2018). DOI: 10.1101/188706. URL: <https://www.biorxiv.org/content/early/2018/04/24/188706>.
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- [1] *Heather Patsolic, Sancar Adali, Joshua T. Vogelstein, Youngser Park, Carey E. Priebe, Gongki Li, and Vince Lyzinski.* “Seeded Graph Matching Via Joint Optimization of Fidelity and Commensurability”. In: *arXiv* (Jan. 2014). eprint: 1401.3813. URL: <http://arxiv.org/abs/1401.3813>.

FUNDING:

The below table shows my direct (total) cost expenditures since being hired, indicating a steady increase >30% per year.

FY15: \$113,761 (\$168,924)
FY16: \$360,123 (\$524,225)
FY17: \$459,523 (\$709,019)
FY18: \$550,011 (\$887,186)
FY19: \$850,836 (\$1,366,308)

Current:

2019 – 22 Accessible technologies for high-throughput, whole-brain reconstructions of molecularly characterized mammalian neurons NIH RO1

Role on project: Co-Investigator (PI: Muller, Miller)

Term: 01-Sept-2019 to 31-Aug-2022

Total budget: \$753,974 (direct cost) \$1,180,445 (total cost)

The overall goal of the proposal is to develop technologies for the brain wide reconstruction of axonal arbors of molecularly defined neurons. The proposal aims at overcoming barriers in neuronal labeling, imaging and computation to achieve this goal, and to develop a technology platform that can be scaled to all neurons of the brain

2019 – 20 Reproducible imaging-based brain growth charts for psychiatry

NIH R01 Research Grant

Role on project: Co-Investigator (PI: Saterthwaite)

Term: 01-Aug-2019 to 31-May-2020

Budget: \$231,276 (direct cost) \$362,861 (total cost)

Aggregate, harmonize, and analyze existing large-scale pediatric neuroimaging datasets to identify normative and clinical brain growth curves.

2019 - Microsoft Research Award

Mirco Soft Research Gift

Role on Project: Investigator

Term: Unrestricted Gift

Budget: 50,000 (total cost)

Research and development of neuroscience and connectomes around neuronal circuit and system modeling, application of time-series-of-graphs and dynamics to neuronal signaling analysis and connectomes, and in the abstractions of matter, math, machines that point toward complex systems composed of low-level components.

2018 – 20 Lifelong Learning Forests

Defense Advanced Research Projects Agency Research Grant FA8650-18-2-7834 (128567)

Role on Project: Investigator

Term: 01-Jul-2018 to 30-Jun-2020

Budget: \$1,123,474 (direct); \$1,839,308 (total)

Lifelong Learning Forests (L2Fs) will learn continuously, selectively adapting to new environments and circumstances utilizing top-down feedback to impact low-level processing, with provable statistical guarantees, while maintaining computational tractability at scale.

2018 – 21 SemiSynBio: Collaborative Research: YeastOns: Neural Networks Implemented in Communication Yeast Cells

National Science Foundation Research Grant (129439)

Role on project: Co-Investigator (PI: Schuman)

Term: 01-Jul-2018 to 30-Jun-2021

Budget: \$172,971 (direct cost) \$263,942 (total cost)

Provide neuroscience and machine learning expertise to guide the design of the computational learning capabilities of the system.

2018 – 19 Connectome Coding at the Synaptic Scale

Schmidt Science Foundation (128503)

Role on Project: Investigator

Term: 01-Jan-2018 to 31-Dec-2019

Budget: \$250,000 (total)

Study learning and plasticity at an unprecedented scale, revealing the dynamics of large populations of synapses comprising an entire local cortical circuit. No previously conducted experiment could answer the questions about the dynamics of large populations of synapses, which is crucial to understanding the learning process.

2017 – 21 Continual Learning Across Synapses, Circuits, and Brain Areas

Defense Advanced Research Projects Agency Research Grant FA8650-18-2-7834 (129061)

Role on project: Co-Investigator (PI: Tolias)

Term: 01-Nov-2017 to 30-Oct-2021

Budget: \$486,666 (direct) \$796,715 (total)

Develop the pre-processing analysis pipeline for the imaging data collected in this project.

2017 – 20 NeuroNex Innovation Award: Towards Automatic Analysis of Multi-Terabyte Cleared Brains

National Science Foundation 1707298

Role on Project: Investigator

Term: 01-Sept-2017 to 31-Aug-2020 (No Cost Extension)

Budget: \$588,758 (direct) \$959,999 (total)

We propose to lower the barrier to connecting data to analyses and models by providing a coherent cloud computational ecosystem that minimizes current bottlenecks in the scientific process.

2017 – 22 Sensorimotor processing, decision making, and internal states: towards a realistic multiscale circuit model of the larval zebrafish brain

NIH Research Grant 1U19NS104653-01 (127940)

Role on Project: Co-Investigator (PI: Engert)

Term: 01-Sept-2017 to 31-Aug-2022

Budget: \$655,206 (direct); \$1,050,000 (total) (JHU sub-award)

Generate a realistic multiscale circuit model of the larval zebrafish's brain – the multiscale virtual fish (MSVF). The model will span spatial ranges from the nanoscale at the synaptic level, to local microcircuits to inter-area connectivity - and its ultimate purpose is to explain and simulate the quantitative and qualitative nature of behavioral output across various timescales.

2017 – 20 CRCNS US-German Res Prop: functional computational anatomy of the auditory cortex

National Institutes of Health Research Grant 1R01DC016784-01 (126308)

Role on Project: Co-Investigator (PI: Ratnanather, J)

Term: 01-July-2017 to 30-June-2020

Budget: \$458,519 (direct cost) \$747,143 (total)

Create a robust computational framework for analyzing the cortical ribbon in a specific region: the auditory cortex.

2017 – 20 Multiscale Generalized Correlation: A Unified Distance-Based Correlation Measure for Dependence Discovery

National Science Foundation Research Grant (132031)

Role on project: Co-Investigator (PI: Cencheng, S)

Term: 01-May-2017 to 30-April-2020

Budget: \$124,189 (direct) \$200,000 (total)

Establish a unified methodology framework for statistical testing in high-dimensional, noisy, big data, through theoretical advancements, comprehensive simulations, and real data experiments.

2016 – 20 D3M: What Would Tukey Do?

Defense Advanced Research Projects Agency Research Grant FA8750-17-2-0112 (125863)

Role on project: Co-Investigator (PI: Priebe, C)

Term: 01-Oct-2016 to 30-Sep-2020

Budget: \$2,746,050 (direct) \$4,406,360 (total)

Develop theory & methods for generating a discoverable archive of data modeling primitives and for automatically selecting model primitives and for composing selected primitives into complex modeling pipelines based on user-specified data and outcome(s) of interest.

Pending:

2019 – 22 High throughput mapping pipeline for incomplete and censored neuroimaging data

NIH / MH-19-148

Role on Project: Co-Investigator (PI: Miller)

Term: 01-Dec-2019 to 30-Nov-2022

Budget: \$1,107,698 (direct) \$1,744,857 (total)

GOAL of Project

2020 – 25 CAREER: Foundational Statistical Theory and Methods for Analysis of Populations of Attributed

NSF 17-537

Role on project: Principal Investigator

Term: 01-Jan-2020 to 31-Dec-2025

Budget: \$384,873 (direct) \$630,230 (total)

The goal is to establish foundational theory and methods for analyzing populations of attributed connectomes.

2020 – 23 Graspy: A python package for rigorous statistical analysis of populations of attributed connectomes

NIH MN-19-147

Role on project: Principal Investigator

Term: 01-Jan-2020 to 30-June-2023

Budget: \$861,240 (direct) \$1,410,279 (total)

The goal of this project is to establish a state-of-the-art toolbox for analysis of connectomes, spanning taxa, scale, and complexity. More specifically, we will develop and extend implementations to enable neurobiologists to 1) estimate latent structure from attributed connectomes, (2) identify meaningful clusters among populations of connectomes, and (3) detect relationships between connectomes and multivariate phenotypes, such as behavior, genetics, and physiology.

2020 – 25 NeuroNex: Enabling Identification and Impact of Synaptic Weight in Functional Networks

NSF 19-563

Role on project: Co-Investigator (PI: Harris)
Term: 01-April 2020 to 31-March-2025
Budget: \$609,294 (direct) \$997,719 (total)
Develop the requisite technology to understand the impact of synaptic weight on functional networks.

2020 – 25 Identifying Neurobehavioral Pathways for Cannabis Use Disorder: Multimodal MRI Investigations of Control and Reward Neural Networks

NIH18-062 - National Institute on Drug Abuse
Role on project: Co-Investigator (PI: Hanson)
Term: 01-April-2020 to 31-March-2025
Budget: \$234,338 (direct) \$383,727 (total)
This project will connect strong behavioral markers of addiction risk, measures of drug use, and measures of brain network connectivity to aid in understanding what causes drug use, versus what is a consequence of it.

2020 – 23 A Novel Framework for Mapping Brain Dynamics and Substrates of Human Cognition Across Species

NIH MH-20-120
Role on project: Co-Investigator (PI: Milham)
Term: 01-July-2020 to 30-June-2023
Budget: \$178,898 (direct) \$292,945 (total)
Develop and apply modern alignment methods to compare and contrast human and non-human brain imaging.

2020 – 23 MBAC: Mouse Brain Atlasing in the Cloud

NIH MN-19-147
Role on project: Co-Investigator (PI: Osten)
Term: 01-July-2020 to 30-June-2023
Budget: \$1,520,570 (direct) \$2,489,933 (total)
Develop and disseminate CloudReg, a cloud brain atlasing tool for microscale whole mouse brains.

2020 – 24 Exploiting latent structure for efficient and robust inference

Role on project: Co-Investigator (PI: Priebe)
Term: 01-July-2020 to 30-June-2024
Budget: \$999,330 (direct) \$1,504,662 (total)
Develop theory and methods for analysis of networks and populations thereof.

2020 – 24 Distributed ensemble neural representations of anxiety states

NIH 0 NS 18-303 BrainInitiative RO1
Role on project: Co-Investigator (PI: Adwanikar)
Term: 01-July-2020 to 30-June-2024
Budget: \$2,672,969 (total)
Imaging the coordinated, multi-area, ensemble neural signaling of anxiety and attention states at cellular-resolution in freely behaving mice.

2020 – 25 The NKI-Rockland Sample II: An open resource of multimodal brain, physiology, and behavior data from a community lifespan sample

NIH 19-056
Role on project: Co-Investigator (PI: Milham)
Term: 01-July-2020 to 30-June-2025
Budget: \$30,713 (direct) \$ 78,891 (total)
We will continue collecting, organizing, and analyzing another cohort of the NKI-Rockland Sample.

Previous:

- 2017 – 18 The Brain Ark**
Defense Advance Research Project Agency Grant 90076467
Role of the Project: Principal Investigator
Characterize the statistical properties of the individual graphs, to identify circuit motifs, both that specialize in a species specific fashion, and that are preserved across species. As a test, will compare the connectomes of sea lions and coyotes.
- 2017 – 18 The International Brain Station**
The Kavli Foundation 90071826
Role of the Project: Principal Investigator
Take the first few steps towards building the international brain station.
- 2017 – 18 Brain Comp Infra: EAGER: BrainLab CI: Collaborative, Community Experiments with**
National Science Foundation ACI-1649880
Role of Project: Co-Investigator (PI: Miller, Burns)
The BrainLab CI prototype system will deploy an experimental-management infrastructure that allows users to construct community-wide experiments that implement data and metadata controls on the inclusion and exclusion of data.
- 2016 – 19 A Scientific Planning Workshop for Coordinating Brain Research Around the Globe**
National Science Foundation 1637376 Part 1 of 2
Role of the Project: Principal Investigator
This travel grant is for the expressed purposes of gathering researchers from around the globe to discuss the new way to further brain research during part one of a two day conference.
- 2016 – 19 A Scientific Planning Workshop for Coordinating Brain Research Around the Globe**
National Science Foundation 1637376 Part 2 of 2
Role of the Project: Principal Investigator
This travel grant is for the expressed purposes of gathering researchers from around the globe to further discuss advancements in brain research during the second part of a two day conference.
- 2015 – 18 From RAGs to Riches: Utilizing Richly Attributed Graphs to Reason from**
Defense Advance Research Project Agency Grant N66001-15-C-40401
Role on Project: Principal Investigator
Multiple, large, multifarious brain imaging datasets are rapidly becoming standards in neuroscience. Yet, we lack the tools to analyze individual datasets, much less populations thereof. Therefore, we will develop theory and methods to analyze and otherwise make such data available.
- 2014 – 16 Scalable Grain Graph Analyses Using Big-Memory, High-IPS Compute Architectures**
Defense Advance Research Project Agency Grant N66001-14-1-4028
Role on Project: Co-Investigator (PI: Burns)
Build software infrastructure to enable analytics on billion node, terabyte sized networks using commodity hardware.
- 2014 - 19 Synaptomes of Mouse and Man**
R01NS092474
Role on project: Co-Investigator (PI: Smith)

The major goals of this project are to discover the synaptic diversity and complexity in mammalian brains, specifically comparing and contrasting humans with mice, the leading experimental animal.

2012 – 15 CRCNS: Data Sharing: The EM open Connectome Project

National Institute of Biomedical Imaging and Bioengineering RO1EB16411

Role of Project: Co-Investigator (PI: Burns)

Develop cyberinfrastructure to support management, visualization, storage, and analysis of large-scale electron microscopy data.

Talks

Invited Talks (Institutional)

- [37] **Joshua T. Vogelstein.** "Open Access to the Brain: a Computer "Connectome" Links Brain Images in Fine Detail". In: JHM Boot Camp, June 2019. URL: <https://neurodata.io/talks/bootcamp19.html>.
- [36] *Jaewon Chung.* "Statistical Methods for Population of Connectomes". In: Organization of Human Brain Mapping, June 2019. URL: <https://neurodata.io/talks/ohbm19.html>.
- [35] **Joshua T. Vogelstein.** "Statistical Foundations For Connectomics". In: Max Planck / HHMI Connectomics Meeting, Apr. 2019. URL: <https://neurodata.io/talks/connectomics19.html>.
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Educational Activities

New Courses Created

- Fall '19 **NeuroData Design I**, EN.580.237/437/637, Course Director, enrollment 46.
- Spring '19 **NeuroData Design II**, EN.580.438/638, Course Director, enrollment 18.
- Fall '18 **NeuroData Design I**, EN.580.237/437/637, Course Director, enrollment 22.
- Spring '17 **NeuroData Design II**, EN.580.238/438/638, Course Director, enrollment 14.
- Winter '17 **BME Research Intersession**, EN.580.574, Course Director, enrollment 6.
- Fall '17 **NeuroData Design I**, EN.580.247/437/637, Course Director, enrollment 15.
- Spring '16 **The Art of Data Science**, EN.580.468, Course Director, enrollment 24.
- Fall '16 **NeuroData Design I**, EN.580.437, Course Director, enrollment 16.
- Spring '15 **Statistical Connectomics**, EN.580.694, Course Director, enrollment 26.

Courses Co-Taught

- Fall '15 **Introduction to Computational Medicine**, Co-Teaching, Course Co-Director.
- Spring '19 **Systems Bioengineering II**, EN.580.422, 2 Lectures.
- Spring '19 **Computational Neuroscience**, AS.080.321, 2 Lectures.
- Spring '18 **Systems Bioengineering II**, EN.580.422, 2 Lectures.

- Spring '18 **Computational Neuroscience**, AS.080.321, 2 Lectures.
 Spring '17 **Systems Bioengineering II**, EN.580.422, 2 Lectures.
 Spring '16 **Systems Bioengineering II**, EN.580.422, 2 Lectures.
 Winter '16 **Introduction to Connectomics**, EN.600.221, 1 Lecture.
 Fall '16 **BME Modeling and Design**, EN.580.111, 1 Lecture.

Educational Workshops

- Summer '19 **DiPy Workshop**, Bloomington, Indiana, 1 day lecture on statistical connectomics.
 Fall '18 **Society for Neuroscience Annual Meeting**, Educational Workshop, San Diego, CA, 1 day lecture on statistical connectomics.
 Fall '17 **Society for Neuroscience Annual Meeting**, Educational Workshop, San Diego, CA, 1 day lecture on statistical connectomics.
 Summer '16 **CRCNS Course on Mining and Modeling of Neuroscience Data**, Redwood Center for Theoretical Neuroscience, University of California, Berkeley, 2 day lecture on statistical connectomics.

Mentorship

Research Track Faculty Mentorship

- 02/19 – now **Hayden Helm, MSE**, Assistant Research Faculty, BME, JHU.
 Leading research efforts developing theory and methods for lifelong learning.
 08/16 – 8/18 **Eric Perlman, PhD**, Assistant Research Scientist, BME, JHU.
 Lead Scientist developing storage, transfer, and visualization solutions for large data in our cloud infrastructure.
 03/16 – now **Jesse Patsolic, MA**, Assistant Research Faculty, BME, JHU.
 Lead developer converting our extensions to decision forests to be merged into sklearn.

Staff Research Scientists

- 10/18 – now **Alex Loftus**, Research Assistant, BME, JHU.
 Current lead developer of NDMG, transitioning from a stand-alone package to be integrated with DiPy.
 09/19 – now **Ross Lawrence, BS**, Research Assistant, BME, JHU.
 Responsible for documenting and bug fixing NDMG.
 07/19 – now **Ronak Mehta, MSE**, Research Assistant, BME, JHU.
 Finalizing three manuscripts on (1) uncertainty forests, (2) time-series dependence quantification, and (3) lifelong learning forests.
 06/18 – 12/19 **Benjamin Falk, PhD**, Research Engineer, BME, JHU.
 Lead software engineer, oversees all development projects, solely responsible for all cloud infrastructure.

Postdoctoral Fellows

- 07/19 – now **Celine Drieu, PhD**, Post-doctoral Fellow, Kavli NDI, JHU.
 Co-Advised by Assistant Prof. Kuchibhotla, Department of Psychological and Brain Sciences. Working on understanding learning and memory using two-photon calcium imaging.
 07/19 – now **Austin Grave, PhD**, Post-doctoral Fellow, Kavli NDI, JHU.
 Co-Advised by Prof. Richard Huganir, Department of Neuroscience. Working on understanding whole brain synaptic plasticity using genetic engineering and light microscopy imaging.
 06/19 – now **Devin Crowley**, Research Assistant, BME, JHU.
 Lead developer of our scalable Python implementation of LDDMM.
 08/18 – now **Jesús Arroyo, PhD**, Post-doctoral Fellow, CIS, JHU.
 Working on graph matching and joint graph embedding.
 07/18 – now **Audrey Branch, PhD**, Post-doctoral Fellow, Kavli NDI, JHU.
 Co-Advised by Prof. Michela Gallagher, extending brain clearing experimental technology from mice to rats. Currently with a manuscript on biorxiv.

09/16 – 08/18 **Cencheng Shen, PhD**, *Post-Doctoral Fellow*, CIS, JHU.
Developed Multiscale Graph Correlation, which is currently the premiere hypothesis testing framework, and about to be integrated into SciPy, by far the world's leading scientific computing package. Currently an Assistant Professor in Department of Statistics at University of Delaware, and still an active collaborator and grantee.

05/16 – 06/17 **Leo Duan, PhD**, *Post-doctoral Fellow*, CIS, JHU.
Went on to do a second postdoc with Leo Dunson (who I did my second postdoc with). Currently an Assistant Professor at University of Florida.

06/16 – 07/17 **Guilherme Franca, PhD**, *Post-doctoral Fellow*, CIS, JHU.
Worked on non-parametric clustering, with an article about to be accepted in PAMI, the leading machine learning journal. Currently a postdoc for Rene Vidal.

Doctoral Student Supervision

08/19 – now **Michael Powell, MSE**, *PhD advisee*, BME, JHU.
Dissertation will focus on explainable artificial intelligence, spearheads collaboration with Andreas Muller, Co-Director of scikit-learn, the world's leading machine learning package.

06/19 – now **Jaewon Chung, MSE**, *PhD advisee*, BME, JHU.
Dissertation will focus on statistics of populations of human networks. Already co-first author and middle author on multiple manuscripts.

08/19 – now **Tommy Athey, BSE**, *PhD advisee*, BME, JHU.
Dissertation will focus on MouseLight project, spearheads collaborations with Prof. Jeremias Sulam and Michael I. Miller.

08/19 – now **Eric Bridgeford, BSE**, *PhD advisee*, Department of Biostatistics, JHU.
Dissertation will focus on statistics of human connectomes and mitigating batch effects. Already first author on several manuscripts under review, and spearheads collaboration with Prof Brian Caffo at Biostatistics.

08/18 – now **Benjamin Pedigo, BSE**, *PhD advisee*, BME, JHU.
Dissertation will focus on analysis and modeling of the world's first whole animal connectome, in collaboration with Marta Zlatic and Albert Cardona (formerly of Janelia Research Campus). Already co-first author and middle author on multiple manuscripts.

08/18 – now **Meghana Madyastha, BSE**, *PhD Co-advisee*, CS, JHU.
Dissertation will focus on computational aspects of accelerating learning and inference using decision forests.

08/16 – now **Vikram Chandrashekhar, BSE**, *PhD advisee*, BME, JHU.
Dissertation has focused on extending LDDMM to whole cleared brain datasets, spearheads collaboration with Prof. Karl Deisseroth's lab at Stanford, one of the world's leading neuroscientists.

08/14 – 01/18 **Tyler Tomita, PhD**, BME, JHU.
Developed Sparse Projection Oblique Randomer Forest in his dissertation, currently the best performing machine learning algorithm on a standard suite of over 100 benchmark problems. Currently a postdoc with Assistant Prof. Chris Honey of Psychology and Brain Sciences.

Visiting Doctoral Student Supervision

03/19 – 09/19 **Derek Pisner**, *PhD advisee*, JHU/ UT Austin.

Master's Student Supervision

06/19 – now **Bijan Varjavand, MS advisee**, BME, JHU.
Submitted manuscript to PAMI on advancing statistics on populations of networks.

06/19 – now **Sambit Panda, MS advisee**, BME, JHU.
Led development of Python implementation of MGC, to be integrated into SciPy.

06/19 – now **Varun Kotharkar, MS advisee**, AMS, JHU.
Investigating theoretical advantages of oblique, as compared to axis-aligned, decision trees.

06/18 – now **Drishti Mannan, MS advisee**, BME, JHU.
Preparing manuscript introducing novel specification for large attributed networks.

06/18 – 05/19 **Jaewon Chung, MSE advisee**, BME, JHU.
Co-first author of manuscript and co-lead developer of Python package for statistical analysis of networks. Currently a BME PhD student in my lab.

08/14 – 06/17 **Greg Kiar, MSE, BME, JHU.**
Lead developer of NDMG, the only existing “soup to nuts” pipeline for both functional and diffusion pipelines; co-first author of manuscript under review. Currently a PhD student at McGill University.

Undergraduate Student Supervision

06/19 – now **Vivek Gopalakrishnan, BSE, BME, JHU.**
Winner of Pistrutto Fellowship.

06/19 – now **Ronan Perry, BSE, BME, JHU.**

06/19 – 12/19 **Richard Guo, BSE, BME, JHU.**

08/14 – 08/18 **Eric Bridgeford, BSE, BME, JHU.**
Currently a PhD student in Biostatistics at JHSPH in my lab.

08/15 – 08/16 **Albert Lee, BSE, BME, JHU.**

06/15 – 12/15 **Ron Boger, BSE, BME, JHU.**
Currently working at a computational medicine start-up in Silicon Valley.

05/15 – 05/16 **Jordan Matelsky, BSE, CS and Neuroscience, JHU.**
Currently a data scientist at APL.

02/15 – 05/16 **Ivan Kuznetsov, BSE, BME, JHU.**
Currently an MD/PhD Candidate at the UPenn, winner of [Soros Fellowship](#).

Summer Interns

Summer '19 **Kareef Ullah, Summer Intern, BME, JHU.**
Will begin undergrad in BME at JHU in Fall 2020

Summer '19 **Shunan Wu, Summer Intern, BME, JHU.**
Applied to BME PhD Program in Fall 2020

Summer '19 **Shiyu Sun, Summer Intern, BME, JHU.**
Applied to BME PhD Program in Fall 2020

Summer '19 **Sander Shulhoff, Summer Intern, BME, JHU.**

Summer '19 **Kiki Zhang, Summer Intern, BME, JHU.**

Summer '18 **Papa Kobina Van Dyck, Summer Intern, BME, JHU.**
Applied to PhD Program in Fall 2019

Examining Committees

2019 **Browne, James, Computer Science, JHU Ph.D. Student, Graduated 2019.**

2019 **Mhembere, Disa, Computer Science, JHU Ph.D. Student, Graduated 2019.**

2018 **Kutten, Kwame, JHU Ph.D. Student, Graduated 2018.**

2018 **Wang, Shangsi, Applied Mathematics and Statistics, JHU Ph.D. Student, Graduated 2018.**

2018 **Tang, Runze, Applied Mathematics and Statistics, JHU Ph.D. Student, Graduated 2018.**

2018 **Lee, Youjin, Biostatistics, JHU Ph.D. Student, Graduated 2018.**

2017 **Zheng, D, Computer Science, JHU Ph.D. Student, Graduated 2017.**

2017 **Binkiewicz, Norbert, Statistics, University of Wisconsin Ph.D. Student, Graduated 2017.**

2016 **Gray-Roncal, Will, Computer Science, JHU Ph.D. Student, Graduated 2016.**

Service

University Service

08/15 – now **Steering Committee, Kavli Neuroscience Discovery Institute (KNDI).**

08/15 – 07/18 **Co-Developer, [Computational Medicine Minor](#).**

05/15 – 07/17 **Co-Founder and Faculty Advisor, [MedHacks](#).**

08/14 – 08/18 **[Director of Undergraduate Studies](#), Institute for Computational Medicine.**

Winter '17 **Faculty Supervisor, MedHacks, <http://medhacks.org/>.**

Winter '16 **Faculty Supervisor, MedHacks, <http://medhacks.org/>.**

Winter '15 **Faculty Supervisor**, *MedHacks*, <http://medhacks.org/>.

Department Service

2019 **Member**, *Search Committee*, BME, Neuroengineering, 2019.

2019 **Member**, *Search Committee*, BME, Data Science, 2019.

2018 **Member**, *Search Committee*, BME, Neuroengineering, 2018.

Journal Service

Editorial Board

Guest Associate Editor, *PLoS Computational Biology*.

Editor, *Neurons, Behavior, Data analysis, and Theory*.

Associate Editor, *Journal of the American Statistical Association*.

Conference and Journal Reviewer

Annals of Applied Statistics (AOAS).

Bioinformatics.

International Conference on Learning Representations (ICLR).

Network Science.

Current Opinion in Neurobiology.

Biophysical Journal.

IEEE International Conference on eScience.

IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP).

IEEE Global Conference on Signal and Information Processing (GlobalSIP).

IEEE Signal Processing Letters.

IEEE Transactions on Signal Processing.

Frontiers in Brain Imaging Methods.

Journal of Machine Learning Research (JMLR).

Journal of Neurophysiology.

Journal of the Royal Statistical Society B (JRSSB).

Nature Communications.

Nature Methods.

Nature Reviews Neuroscience.

Neural Computation.

Neural Information Processing Systems (Neurips).

NeuroImage.

Neuroinformatics.

PLoS One.

PLoS Computational Biology.

Conferences and Hackathon Organizer

Winter '19 **Track Organizer**, *AI in Healthcare: From Bench to Bedside*, Organizer for Breakout Topic Sessions on artificial intelligence.

Winter '19 **Organizer**, *Decision Forest Hackathon*.

Summer '19 **Organizer**, *NeuroData Workshop*, <https://neurodata.devpost.com>, Hackashop to train brain scientists in machine learning for big data (~ 50) participants from around the country..

March '19 **Organizer**, *Neuro Reproducibility Hackashop*, <https://brainx3.io/>, Hackashop to train brain scientists in best practices in reproducible science, co-organized with two startups: Vathes, LLC and Gigantum (~ 50 participants).

Spring '18 **Organizer**, *NeuroData Hackathon*.

Fall '17 **Organizer**, *NeuroData Mini-Hackathon*.

- Summer '17 **Organizer**, *NeuroStorm*, <https://brainx2.io>, Workshop to bring together thought leaders from academia, national labs, industry, and non-profits around the world to take next steps towards accelerating brain science discovery in the cloud (~ 50 participants and 5 observers from funding institutions).
- Spring '16 **Organizer**, *Global Brain Workshop*, <http://brainx.io>, First ever international Brain Initiative workshop, bringing together leaders from around the world, covered by Nature and Science (~ 75 participants).
- Fall '16 **Co-Organizer**, *Brains and Bits: Neuroscience Meets Machine Learning*, *NIPS Workshop*, http://www.stat.ucla.edu/~akfletcher/brainsbits_overview.html.
- Winter '15 **Organizer**, *Hack@NeuroData*, <http://hack.neurodata.io/>.
- Fall '15 **Co-Organizer**, *BigNeuro2015: Making Sense of Big Neural Data*, *NIPS Workshop*, <http://neurodata.io/bigneuro2015>.
- Fall '12 **Co-Organizer**, *Scaling up EM Connectomics Conference*, The world's first connectomics workshop, now run annually alternating between Janelia Research and Max Planck locations (~ 80 participants).

Awards and Recognition

Individual

- 2002 **Dean's List**, Washington University.

Shared

- 2019 **Kavli NDI Distinguished Postdoctoral Fellow**, Celine Drieu, PhD.
- 2019 **Kavli NDI Distinguished Postdoctoral Fellow**, Austin Graves, PhD.
- 2019 **Winner of Pistrutto Fellowship.**, Vivek Gopalakrishnan.
- 2017 **Kavli NDI Distinguished Postdoctoral Fellow**, Audrey Branch, PhD.
- 2017 **Best Presentation Award HPDC**, Mhembere et al. (2017).
- 2017 **Nonparametric Statistics of the American Statistical Association Student Paper Award**, Lee et al. (2017).
- 2014 **F1000 Prime Recommended**, Vogelstein et al. (2014).
- 2013 **Spotlight**, *Neural Information Processing Systems (NIPS)*.
- 2011 **Trainee Abstract Award**, *Organization for Human Brain Mapping*.
- 2008 **Spotlight**, *Computational and Systems Neuroscience (CoSyNe)*.

Other Media

Earned Media Coverage

- 2019 **Johns Hopkins Medicine**, *BME Pioneers: Joshua Vogelstein*, BME Pioneers.
- 2019 **Johns Hopkins Medicine**, *Technology Connecting the Brain to the Human Experience*.
- 2018 **J. M. Perkel.**, *Web service makes big data available to neuroscientists*, Nature.
- 2016 **Emerging Technology from the arXiv**, *Three Grand Challenges for Brain Science That Can Be Solved in 10 Years*, MIT.
- 2016 **P. Patel.**, *Johns Hopkins researchers want to use big data to chart the brain*, Johns Hopkins University.
- 2016 **S. Reardon.**, *Worldwide brain-mapping project sparks excitement — an concern*, Nature.
- 2016 **E. Underwood.**, *International brain projects proposed*, Science.
- 2016 **National Institutes of Health**, *International Brain Projects Considered*, BRAIN initiative.
- 2016 **Office of the Spokesperson**, *International Brain Initiative Launch and VIP Dialog: Towards an International Brain Station*, US Department of State.
- 2016 **The Kavli Foundation**, *International Brain Initiative*, Kavli.

- 2015 **Dale Keiger**, [The Open Connectome Project takes a close look at the brain](#), Johns Hopkins Magazine.
- 2014 **S. Begley**, [Fly brain 'atlas' opens door to linking human neurons to actions](#), Reuters.
- 2014 **L. Gatlin**, [Johns Hopkins mathematician receives grant to support study of brain's circuitry](#), Johns Hopkins University.
- 2014 **T. O'Leary and E. Marder**, [Mapping Neural Activation onto Behavior in an Entire Animal](#), Science.
- 2014 **L. Sanders**, [Ten thousand neurons linked to behaviors in fly](#), ScienceNews.
- 2014 **D. Son and J. Lee**, [Research Highlights](#), Nature.
- 2014 **K. Yandell**, [Linking Neurons to Behaviors](#), TheScientist.
- 2014 **B. Yirka**, [Researchers create a reference atlas for neural circuits in fruit fly larvae](#), MedicalXpress.
- 2012 **C. B. Begg and M. C. Pike**, [Comment on "The Predictive Capacity of Personal Genome Sequencing"](#), Science.
- 2012 **B. Thomas**, ["Open Access to the Brain" – Podcast 1: Joshua Vogelstein](#), The Connectome Podcast.
- 2012 **E. J. Topol**, [Comment on "The Predictive Capacity of Personal Genome Sequencing"](#), Science.

Professional/Social Media Presence

[@neuro_data](#), My twitter account with a following of approximately 6,000.

Translation / Technology Transfer Activities

Open Datasets

- 2017 – now **Allen Atlas**, These anatomical reference atlases illustrate the adult mouse brain in coronal and sagittal planes of section. They are the spatial framework for datasets such as in situ hybridization, cell projection maps, and in vitro cell characterization. More information at atlas.brain-map.org.
- 2015 – now **Amunts et al. (2015)**, Enabling an unprecedented look into the human brain, BigBrain spans micro- and macro-scopic scales. While previously available reference brains have been restricted to a single scale, such as whole-brain magnetic resonance imaging in humans or electron microscopy of small sections from small animals, BigBrain is an ultrahigh-resolution three-dimensional model of a full human brain at 20 micrometer resolution, coming closer to touching both camps than any previous dataset.
- 2015 – now **Bhatla et al. (2015)**, Using high-pressure freezing, serial section transmission electron microscopy (ssTEM) imaging, digital alignment and manual tracing, Nikhil Bhatla and Rita Droste in Bob Horvitz's Lab reconstructed the anterior half of the *C. elegans* feeding organ, the pharynx. Volumes are available for three adult hermaphrodite worms and include volumetric tracing of all neurons and selected cell types, as well as synapses identified from the I2 neurons. Sections were approximately 50 nm thick with an image resolution of 2 nm per pixel. The largest volume comprises 1199 slices. These data were published in a paper entitled "Distinct neural circuits control rhythm inhibition and spitting by the myogenic pharynx of *C. elegans*" (Current Biology, 2015).

- 2016 – now [Bloss et al. \(2016\)](#), Neuronal circuit function is governed by precise patterns of connectivity between specialized groups of neurons. The diversity of GABAergic interneurons is a hallmark of cortical circuits, yet little is known about their targeting to individual postsynaptic dendrites. We examined synaptic connectivity between molecularly defined inhibitory interneurons and CA1 pyramidal cell dendrites using correlative light-electron microscopy and large-volume array tomography. We show that interneurons can be highly selective in their connectivity to specific dendritic branch types and, furthermore, exhibit precisely targeted connectivity to the origin or end of individual branches. Computational simulations indicate that the observed subcellular targeting enables control over the nonlinear integration of synaptic input or the initiation and backpropagation of action potentials in a branchselective manner. Our results demonstrate that connectivity between interneurons and pyramidal cell dendrites is more precise and spatially segregated than previously appreciated, which may be a critical determinant of how inhibition shapes dendritic computation.
- 2018 – now [Bloss et al. \(2018\)](#), CA1 pyramidal neurons are a major output of the hippocampus and encode features of experience that constitute episodic memories. Feature-selective firing of these neurons results from the dendritic integration of inputs from multiple brain regions. While it is known that synchronous activation of spatially clustered inputs can contribute to firing through the generation of dendritic spikes, there is no established mechanism for spatiotemporal synaptic clustering. Here we show that single presynaptic axons form multiple, spatially clustered inputs onto the distal, but not proximal, dendrites of CA1 pyramidal neurons. These compound connections exhibit ultrastructural features indicative of strong synapses and occur much more commonly in entorhinal than in thalamic afferents. Computational simulations revealed that compound connections depolarize dendrites in a biophysically efficient manner, owing to their inherent spatiotemporal clustering. Our results suggest that distinct afferent projections use different connectivity motifs that differentially contribute to dendritic integration.
- 2011 – now [Bock et al. \(2011\)](#), Layer 2/3 - Davi Bock, Ph.D. and Wei-Chung Allen Lee, Ph.D., in the laboratory of Clay Reid, M.D., Ph.D. acquired a beautiful volume of mouse primary visual cortical data, spanning layers 1, 2/3, and upper layer 4. In addition to the electron microscope (EM) data, they used two-photon microscopy to determine the functional properties of about 14 of the cells in the same volume. Images were collected at approximately 4x4x45 cubic nanometers with a total volume of approximately 450x350x50 cubic microns.
- 2018 – now [Branch \(2018\)](#), Adult generated neurons in aging M. musculus (iDisco).
- 2013 – now [Bumbarger et al. \(2013\)](#), These serial thin section data were generated by Dan Bumbarger in Ralf Sommer's lab in order to compare the pharyngeal connectomes of the pharyngeal nervous system between *Caenorhabditis elegans* and *Pristionchus pacificus*. (Cell 2013, 152:109–119). In *P. pacificus* they found clearly homologous neurons for all of the 20 pharyngeal neurons in *C. elegans*, but were surprised to uncover a massive rewiring of synaptic connectivity between the two species. These changes seem to correlate with known behavioral difference, most interestingly with the novel predatory feeding behaviors found in Diplogastrid nematodes such as *P. pacificus*.
- 2015 – now [Collman et al. \(2015\)](#), Synapses of the mammalian CNS are diverse in size, structure, molecular composition, and function. Synapses in their myriad variations are fundamental to neural circuit development, homeostasis, plasticity, and memory storage. Unfortunately, quantitative analysis and mapping of the brain's heterogeneous synapse populations has been limited by the lack of adequate single-synapse measurement methods. Electron microscopy (EM) is the definitive means to recognize and measure individual synaptic contacts, but EM has only limited abilities to measure the molecular composition of synapses. This report describes conjugate array tomography (AT), a volumetric imaging method that integrates immunofluorescence and EM imaging modalities in voxel-conjugate fashion. We illustrate the use of conjugate AT to advance the proteomic measurement of EM-validated single-synapse analysis in a study of mouse cortex.

- 2015 – now [Deisseroth et al. \(2015\)](#), Twelve CLARITY mouse brains (5 wild type controls and 7 behaviorally challenged) were prepared by Li Ye, and imaged using CLARITY-Optimized Light-sheet Microscopy (COLM) (whole brain COLM imaging and data stitching performed by R. Tomer, in preparation).
- 2016 – now [Dyer et al. \(2016\)](#), Methods for resolving the 3D microstructure of the brain typically start by thinly slicing and staining the brain, and then imaging each individual section with visible light photons or electrons. In contrast, X-rays can be used to image thick samples, providing a rapid approach for producing large 3D brain maps without sectioning. Here we demonstrate the use of synchrotron X-ray microtomography (microCT) for producing mesoscale (1 cubic micron resolution) brain maps from millimeter-scale volumes of mouse brain. We introduce a pipeline for microCT-based brain mapping that combines methods for sample preparation, imaging, automated segmentation of image volumes into cells and blood vessels, and statistical analysis of the resulting brain structures. Our results demonstrate that X-ray tomography promises rapid quantification of large brain volumes, complementing other brain mapping and connectomics efforts.
- 2015 – now [Harris et al. \(2015\)](#), From the laboratory of Kristen M Harris, PhD, three volumes of hippocampal CA1 neuropil in adult rat were imaged at an XY resolution of 2 nm on serial sections of 50-60 nm thickness. All axons, dendrites, glia, and synapses were reconstructed in a cube surrounding a large dendritic spine, a cylinder surrounding an oblique dendritic segment, and a parallelepiped surrounding an apical dendritic segment.
- 2017 – now [Hildebrand et al. \(2017\)](#), Hildebrand and colleagues acquired a multi-resolution serial-section electron microscopy data set containing the anterior quarter of a 5.5 days post fertilization larval zebrafish, including its complete brain. A draft projectome consisting of central and peripheral myelinated neurons was then reconstructed. Electron micrographs and reconstructions are available for view in CATMAID. A manuscript describing the data and methods used to generate it has been published in Nature.
- 2015 – now [Kasthuri et al. \(2015\)](#), We describe automated technologies to probe the structure of neural tissue at nanometer resolution and use them to generate a saturated reconstruction of a sub-volume of mouse neocortex in which all cellular objects (axons, dendrites, and glia) and many sub-cellular components (synapses, synaptic vesicles, spines, spine apparatus, postsynaptic densities, and mitochondria) are rendered and itemized in a database. We explore these data to study physical properties of brain tissue. For example, by tracing the trajectories of all excitatory axons and noting their juxtapositions, both synaptic and non-synaptic, with every dendritic spine we refute the idea that physical proximity is sufficient to predict synaptic connectivity (the so-called Peters' rule). This online minable database provides general access to the intrinsic complexity of the neocortex and enables further data-driven inquiries.
- 2016 – now [Lee et al. \(2016\)](#), Electron Microscopy data used in a study of an excitatory network in Mouse V1.
- 2015 – now [Micheva et al. \(2015\)](#), Multi-channel array tomography data which is barrel cortex from an adult mouse (C57BL/6J).
- 2015 – now [Ohyama et al. \(2015\)](#), Understanding brain function and development would be facilitated enormously by being able to perform all experiments on the basis of known circuitry. Over 20 laboratories world wide have contributed towards the reconstruction of neurons in the central nervous system of *Drosophila* larva, led by the Cardona lab at HHMI Janelia. Here, we see a side view of the approximately 7,000 neurons reconstructed so far, either in full or partially, of the approximately 12,000 neurons of this animal. The 0111-8 data set was originally sectioned and imaged by Richard D. Fetter and his two tech assistants, and funded by the HHMI Janelia Fly EM Project Team. There are now many more papers now using the 0111-8 data (see publications below).
- 2013 – now [Takemura et al. \(2013\)](#), The right part of the brain of a wild-type Oregon R female fly was serially sectioned into 40-nm slices. A total of 1,769 sections, traversing the medulla and downstream neuropils, were imaged at a magnification of 35,000X.

- 2019 – now [Templier et al. \(2019\)](#), The non-destructive collection of ultrathin sections onto silicon wafers for post-embedding staining and volumetric correlative light and electron microscopy traditionally requires exquisite manual skills and is tedious and unreliable. In MagC introduced here, sample blocks are augmented with a magnetic resin enabling remote actuation and collection of hundreds of sections on wafer. MagC allowed the correlative visualization of neuroanatomical tracers within their ultrastructural volumetric electron microscopy context.
- 2017 – now [Tobin et al. \(2017\)](#), Wiring variations that enable and constrain neural computation in a sensory microcircuit.
- 2016 – now [Wanner et al. \(2016\)](#), Large-scale reconstructions of neuronal populations are critical for structural analyses of neuronal cell types and circuits. Dense reconstructions of neurons from image data require ultrastructural resolution throughout large volumes, which can be achieved by automated volumetric electron microscopy (EM) techniques. We used serial block face scanning EM (SBEM) and conductive sample embedding to acquire an image stack from an olfactory bulb (OB) of a zebrafish larva at a voxel resolution of $9.25 \times 9.25 \times 25$ nm³ (Wanner et al., 2016). Skeletons of 1,022 neurons, $\sim 98\%$ of all neurons in the OB, were reconstructed by manual tracing and efficient error correction procedures.
- 2014 – now [Weiler \(2014\)](#), The lab of Stephen J Smith has been developing array tomography technology for nearly a decade (Micheva et al., 2007). This technology is unique in its ability to measure many proteins (20 or more) in biological tissue samples with superresolution precision. In this dataset, we are using array tomography to uncover molecular signatures synaptic diversity (O'Rourke et al., 2012), which is fundamental to neural circuit design and function. Images generously donated by Nick Weiler.
- 2015 – now [Randlett et al. \(2015\)](#), Light microscopy data.
- [Open-source Software: Active](#)
- 2011 – now [OCP](#), The Open Connectome Project.
- 2016 – now [Non-Parametric-Clustering](#).
- 2018 – now [MGC \(Non-parametric hypothesis testing\)](#), Multiscale Graph Correlation (MGC) is a framework for universally consistent testing high-dimensional and non-Euclidean data..
- 2018 – now [ndcloud \(NeuroData Cloud\)](#), The deployment of tools which support the Open Connectome Project.
- 2018 – now [LOL \(Supervised dimensionality reduction\)](#), Linear Optimal Low-rank (LOL) projection for improved classification performance in high-dimensional classification tasks.
- 2018 – now [m2g \(MR graph analysis\)](#), m2g uses diffusion MRI data from individuals to estimate connectomes reliably and scalably..
- 2019 – now [Sparse Projection Oblique Randomer Forests \(Classification and regression\)](#), SPORF is an improved random forest algorithm that achieves better accuracy and scaling than previous implementations on a standard suite of >100 benchmark problems..
- 2019 – now [reg \(Image registration\)](#), Performs non-linear affine and deformable image registration..
- 2019 – now [Uncertainty-Forest](#), A Python package containing estimation procedures for posterior distributions, conditional entropy, and mutual information between random variables X and Y.
- 2019 – now [Open-Data-Registry](#), This bucket contains multiple neuroimaging datasets (as Neuroglancer Precomputed Volumes) across multiple modalities and scales, ranging from nanoscale (electron microscopy), to microscale (cleared lightsheet microscopy and array tomography), and mesoscale (structural and functional magnetic resonance imaging). Additionally, many of the datasets include segmentations and meshes..
- 2019 – now [neuroparc](#), This repository contains a number of useful parcellations, templates, masks, and transforms to (and from) MNI152NLin6 space. The files are named according to the BIDs specification..
- 2019 – now [GraSPy \(Graph Statistics\)](#), Utilities and algorithms designed for processing and analysis of graphs with specialized graph statistical algorithms.

Open-source Software: Contributed

- 2017 **boss**, Developed core functionality.
- 2017 – 2018 **render**, Added cloud support.
- 2018 **igraph**, Added spectral clustering functionality.
- 2018 – 2019 **neuroglancer**, Added multispectral support to enable light microscopy data use.
- 2019 **cloud-volume**, Added support for additional file types.
- 2019 **C-PAC**, Added streamlined reproducible pipeline.
- 2019 **scipy**, Added mgc, a state of the art method for hypothesis testing we developed in the lab.

Open-source Software: Archived

- 2011 – 2016 **oopsi (Calcium Spike Sorting)**, Model-based spike train inference from calcium imaging.
- 2011 – 2017 **ndstore**, Scalable database cluster for the spatial analysis and annotation of high-throughput brain imaging data.
- 2012 – 2017 **FlashGraph (Scalable Analytics)**, General-purpose graph analysis framework that exposes vertex-centric programming interface for users to express varieties of graph algorithms.
- 2012 – 2017 **FlashX (Scalable machine learning)**, A matrix computation engine that provides a small set of generalized matrix operations on sparse matrices and dense matrices to express varieties of data mining and machine learning algorithms.
- 2015 **VESICLE (EM Synapse Detection)**, Reference synapse detection from serial electron microscopy data.
- 2015 – 2018 **ndviz**, Web visualization and analysis tools for neuroimaging datasets, powered by Neuroglancer.
- 2015 **CAJAL**, A MATLAB API that provides a simple to use interface with Open Connectome Project servers and provides RAMON Objects, unit tests, configuration scripts, and utilities.
- 2015 – 2016 **DMG**, An implementation of a distributed multigrid Poisson solver for image stitching, smoothing, and sharpening.
- 2017 – 2019 **ndex**, Python 3 command-line program to exchange (download/upload) image data with NeuroData's cloud deployment of APL's BOSS spatial database.
- 2017 – 2018 **ndwebtools**, ndwebtools (ndweb) is a Django application to provide a user-friendly interface for interacting with NeuroData resources and data.
- 2017 – 2019 **knor (Clustering)**, Python version of knor, a highly optimized and fast library for computing k-means in parallel with accelerations for Non-Uniform Memory Access (NUMA) architectures.
- 2017 – 2018 **MEDA (Matrix Exploratory Data Analysis)**, A python package for matrix exploratory data analysis.
- 2017 – 2019 **SynapseAnalysis (Synapse Detection)**, A framework to evaluate synaptic antibodies for array tomography applications.

Consultancy

- 2017 **Consultant**, *Greenspring Associates*.
- 2016 **Consultant**, *Scanadu*.

Advisory Board Appointments

- 10/18 – now **Advisory Board**, *Mind-X*.
- 01/17 – now **Advisory Board**, *PivotalPath*.

Startups

- 01/17 – now **Co-Founder**, *gigantum*.
- 01/16 – now **Co-Founder**, *d8alab*.
- 01/11 – now **Co-Founder & Co-Director**, *NeuroData* (formerly Open Connectome Project).