

NeuroView

How private foundations and governments helped build theoretical neuroscience

Xiao-Jing Wang^{1,*}¹Center for Neural Science, New York University, New York, NY, USA*Correspondence: xjwang@nyu.edu<https://doi.org/10.1016/j.neuron.2026.09.003>

Visionary philanthropy and governments worked with scientists to develop theoretical and computational neuroscience, through establishing centers with “local critical mass,” training “outsiders,” and fostering theory-experiment collaborations. This NeuroView traces how those bets shaped the field, helping launch AI and computational psychiatry.

In the 1980s, a confluence of developments took place, leading to the emergence of theoretical and computational neuroscience as we know it today. Following the footsteps of Alan Hodgkin and Andrew Huxley, who pioneered mathematical modeling in membrane biophysics, models of single neurons and synaptic transmission flourished in concert with experimental progress.¹ On the other hand, neurophysiology with animals raised the hope of linking neurons and neural networks to perception² and movement.³ Quantitative data analysis and modeling became an integrated part of systems neuroscience, and this perspective motivated the founding of the Center for Neural Science at New York University by Tony Movshon in 1987. In cognitive science and computer science, David Marr published his influential book; David Rumelhart, Jay McClelland, Geoff Hinton, and their colleagues developed ideas and algorithms⁴ that presaged today's AI revolution. John Hopfield's model of neural networks⁵ impressed a number of physicists so much that they switched to neuroscience. Mathematical modeling was “in the air,” and there was an increasing need to draw young talents from physical, mathematical, and engineering fields. In response, the first computation and neural systems graduate program was established in 1986 at Caltech. Around the same time, Ellen Hildreth and Tony Movshon started a Computational Neuroscience: Vision summer course at the Cold Spring Harbor Laboratory in Long Island. In 1988, Jim Bower and Christof Koch from Caltech launched the Methods in

Computational Neuroscience (MCN) summer course at the Marine Biological Laboratory in Woods Hole, Cape Cod, Massachusetts (partly supported by the National Institutes of Health [NIH]). Almost simultaneously, a “manifesto” for the field of computational neuroscience was published.⁶ In the same year, Richard Nakamura started the first program in computational neuroscience at the National Institute of Mental Health and a dedicated study section at NIH for theory in neuroscience. Therefore, it could be said that the year of 1988 marked the official start of our field.

In 1990, Hirsh Cohen (1925–2020), an applied mathematician who had worked on the Hodgkin-Huxley model, retired from the IBM Research Lab in Yorktown, New York. At 65, he immediately started a second full-time career as a grant officer at the Alfred P. Sloan Foundation.⁷ His two initiatives were a groundbreaking map of large-scale structure in the universe (the Sloan Digital Sky Survey) and a new program in theoretical neuroscience, resonating with Immanuel Kant's famous line about the “starry heavens above” and the “moral law within [the brain/mind].” Not knowing what the field was about, some top universities did not respond to Sloan's solicitation; ten universities applied, and five were selected: Brandeis University, Caltech, New York University (NYU), Salk Institute, and University of California, San Francisco (UCSF). The consortium of five Sloan Centers of Theoretical Neuroscience opened the door in 1994. Personally, having switched from theoretical physics to computational neuroscience in 1987,

I was on the faculty at University of Pittsburgh when I heard the news. In 1995, I joined Brandeis thanks to the initiative. NYU benefitted from the Sloan support to hire three theorist faculty: John Rinzel, Eero Simoncelli, and Nava Rubin. Most of the funds, however, were devoted to supporting postdoctoral fellows. Indeed, the original Sloan Centers were explicitly training programs.

In contrast to grants broadly distributed to individuals, funding of centers creates “local critical mass”: each site has a sufficiently large community with a shared intellectual mission, in an environment where researchers develop new ideas and methods in a snowballing cascade. The centers drew attention, attracting young talents with various backgrounds and expertise who wanted to transition to the field. Notably, all centers deliberately had experimentalists as program directors: Eve Marder at Brandeis, Richard Andersen at Caltech, Bob Shapley at NYU, Tom Albright at Salk, and Steve Lisberger at UCSF. The rationale was explained by a representative of the Sloan Centers:

We believe that the nature of the Theoretical Neurobiology Centers, bringing young theoreticians together with sympathetic senior experimenters in a sufficiently large group, has been responsible for this successful output. In a group, theoreticians may learn the limits of experimental capabilities and the details required for useful theory in an environment, which is not as inhibiting or embarrassing

as it might be if they were isolated appointments. In addition, they have companions in theoretical discussions. Thus, the [centers] are designed to have a special nurturing role for the transition from mathematics or the physical sciences to biology.

The success of the Sloan initiative was swift, as shown by the first batch of trainees that included (with their names and current faculty positions): Kwabena Boahen (Stanford University), Marcelo Camperi (San Francisco State University), Matteo Carandini (University College London [UCL]), Dmitri Chklovskii (Flatiron Institute at the James Simons Foundation), Mike Deweese (University of California, Berkeley [UC Berkeley]), Fabrizio Gabbiani (Rice University), Geoff Goodhill (Washington University), Marco Idiart (Federal University of Rio Grande do Sul, Brazil), Dieter Jaeger (Georgia Tech), Michael Lewicki (Carnegie Mellon University), Victor Matveev (New Jersey Tech), Farzan Nadim (Rutgers University), Pamela Reinagel (University of California, San Diego [UCSD]), Dario Ringach (University of California, Los Angeles), Philip Sabes (UCSF), Diana K. Smetters (Google), Frederic Theunissen (UC Berkeley), and Tony Zador (Cold Spring Harbor Laboratory).

Sloan Foundation's funding lasted 9 years, until 2003. As its support came to an end, Jerome (Jerry) Swartz, an engineer who developed the handheld barcode scanner and was interested in computational neuroscience, decided to take over from the Sloan Foundation. Jerry hired Hirsh as his advisor to ensure continuity. For over 25 years, the Swartz Foundation expanded its portfolio to Cold Spring Harbor Laboratory, Columbia, Harvard, Princeton, UCSD, University of Washington, and Yale. Jerry also sponsored the Swartz Prize of Theoretical and Computational Neuroscience, administered by the Society for Neuroscience.

Over the years, this initiative helped hundreds make the transition to computational neuroscience; many are now leaders of the field in the US and around the world. A small sample includes (with current affiliation) Albert Compte (the Institut d'Investigacions Biomèdiques August Pi i Sunyer in Barcelona, Spain), Tatiana Engel (Princeton), Surya Ganguli (Stanford University),

Kiyohito Iigaya (Columbia), Leslie M. Kay (University of Chicago), Ann Kennedy (Scripps Research Institute), Chung-Chuan Lo (Tsinghua University in Taiwan), Bijan Pesaran (University of Pennsylvania), Astrid Prinz (Emory University), Leslie Osborne (NIH/NINDS), Kanaka Rajan (Harvard), Alfonso Renart (Champalimaud Foundation in Lisbon, Portugal), and Tatyana Sharpee (Salk Institute). The Swartz Foundation also supported individual computational neuroscientists outside the centers, including Chengcheng Huang (University of Pittsburgh), Agostina Palmigiano (UCL/Gatsby), and Gregory Handy (University of Minnesota).

The Sloan and Swartz Centers were effective at fostering the new field in multiple ways. First, fellows learned to appreciate biology and ensure that theory is directly connected with data and experimentation. Second, conversely, experimentalists became familiar with mathematical modeling through working with theorists, attending talks, and informally chatting with neighbors. Such experience shaped their perspectives and prepared them to pursue computational collaborations in their future careers. Third, fellowships afforded labs to explore new directions and topics that were not part of conventional federal grants. Fourth, there was a spillover effect. Many young theorists were drawn to those centers, even though they were not directly supported by a Sloan or Swartz fellowship; just to mention a few: Wulfram Gerstner, Nicolas Brunel, and Stefano Fusi at Brandeis; Adrienne Fairhall at Princeton; and Ila Fiete at Caltech. Eric Shea-Brown wrote about his experience at NYU:

Inside the Swartz Center so much community was built. It didn't matter who exactly was an official Swartz fellow—we were surrounded by fellows in the true sense of the word. I remember how Jaime de la Rocha, Brent Doiron, and others rallied around me as I stepped onto the job market. One would think all signs pointed toward competition. They were leaders of work which we had done together, and this work was at the center of all of our portfolios when we were all on the

same market at more or less the same time! But instead of competition it was the opposite—uncannily like being on the same football team. I can still hear the echoes of Jaime literally chanting “get the job, get the job, get the job” as I was practicing my job talk with him, Brent, and others late one night. The result was, of course, half a lifetime of scientific joy, collaboration, friendship, and a million times more ideas and results than would have come from being fellows in name only.

I would be remiss if I did not mention, albeit briefly, scientific gatherings for dissemination of information, exchanges of ideas, and building a community. I remember an early annual meeting of the five Sloan Centers in Santa Fe, New Mexico, where Sebastian Seung was invited as an outside speaker to give two long lectures on his line attractor model, appealing to many in the audience. Mark Goldman recalled the first time he attended a Sloan Centers meeting, as a PhD student in physics: “It was very fun for the first time to see so many other students working on a range of problems across computational neuroscience.” Bijan Pesaran wrote: “I remember clearly the generations of meetings over the years. A wonderful gift to our field!”

The centers ran seminar series popular across departments; some had annual symposia. When I was at Yale, in 2010, our center organized a symposium on computational psychiatry, at the dawn of this nascent field. The following year's symposium (Figure 1) was devoted to large-scale brain circuits, which represent a hot topic today, when it is possible to monitor activities of many neurons across multiple brain regions in behaving animals. These are but a few anecdotes of collective activities that spurred frontiers of research.

While it is not possible to cover extensively the history of summer courses in our field, the critical role of these courses must be highlighted. MCN made equally notable contributions to training converts from physics, math, computer science, etc., in neurobiology and experimentalists in mathematical modeling. Moreover, starting with Bower and Koch, MCN

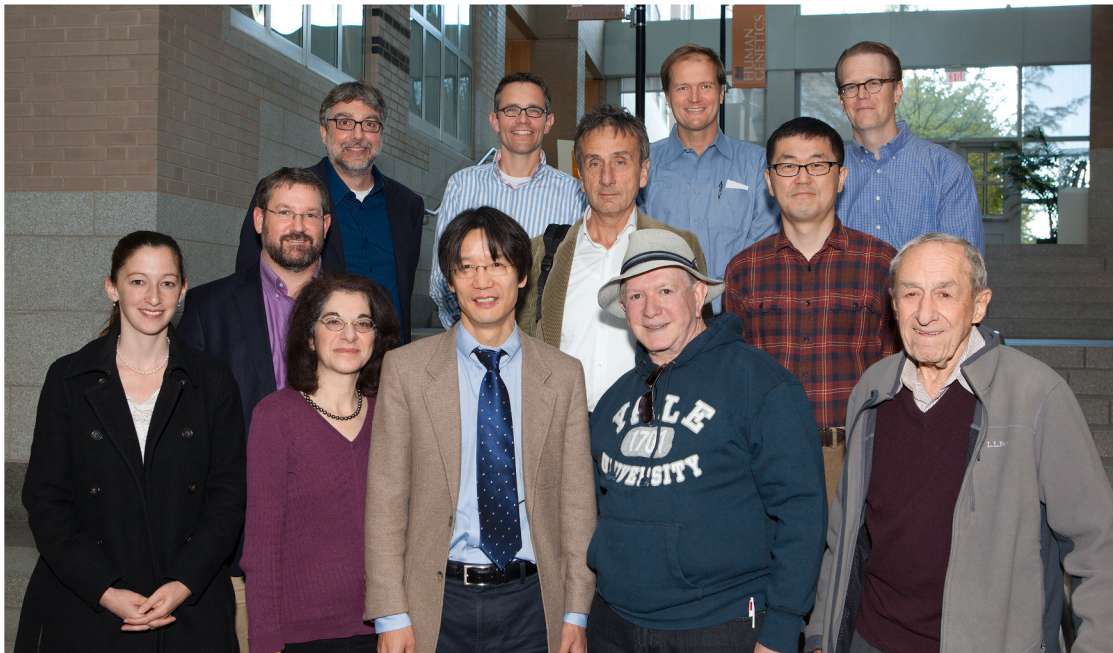


Figure 1. 5th Annual Swartz Symposium at Yale University, “The Organization and Function of Large-Scale Brain Circuits,” October 28, 2011
From right to left, first row: Hirsh Cohen, Jerry Swartz, Xiao-Jing Wang, Helen Barbas, Dani Bassett; second row: Daeyeol Lee, Henry Kennedy, Joshua Gordon; third row: Mark Laubach, Karel Svoboda, Pieter Roelfsema, Olaf Sporns.

directors consciously paired theorists and experimentalists (who may be collaborators) to give back-to-back lectures so that students learned how wet lab experiments and modeling worked together. The MCN served as a template for other summer courses, including the Cajal course in computational neuroscience in Europe (starting in 1996) and Computational and Cognitive Neuroscience (CCN) summer course at the Cold Spring Harbor Asia site in China (launched in 2010).

As the field grew, trainees went on to be principal investigators (PIs), and their labs depended on support from government agencies. It was soon recognized that conventional review panels (study sections) at the NIH were not optimal for assessing theoretical grant proposals. Furthermore, a new mechanism was required specifically to fund collaborations between theorists and experimentalists. Thus, in 2002, the Collaborative Research in Computational Neuroscience (CRCNS) program was born. It was a joint initiative between the National Science Foundation (NSF) and the NIH to support innovative, interdisciplinary research bridging theoretical and experimental neurosciences. Generally, a

CRCNS grant application is jointly proposed by an experimentalist and a theorist (sometimes more than two PIs). So, a theorist is encouraged to go beyond building a mathematical model for a published experimental observation (which, of course, is perfectly fine). Through CRCNS, the theorist would work with an experimentalist from the beginning to define a scientific question, formulate a hypothesis, and design the experiment and modeling accordingly. The back-and-forth interactions continue throughout a grant's cycle of 5 years, and the partnership often lasts well beyond. Furthermore, the NIH-NSF joint nature of the CRCNS program meant that grant applications were reviewed by both experimental neuroscientists and scientists knowledgeable in relevant mathematical, physical, and engineering fields.

Foundations and governments played complementary roles. Private funders have flexibility, bringing a personal approach to their giving. Outside of the US, David John Sainsbury established the Gatsby Computational Neuroscience Unit at UCL in 1998. Geoff Hinton served as the inaugural director, joined by Peter Dayan, who co-wrote a major textbook⁸ with Larry Abbott and succeeded Hinton

to lead the Gatsby center between 2002 and 2017. When James and Marilyn Simons decided to fund neuroscience research, their foundation chose selective themes, such as research on autism and the Simons Collaboration on the Global Brain. On the other hand, a government can scale up the support of a nascent field. In Germany, Christiane Buchholz at the federal Ministry for Education and Research worked with Andreas Herz and others, with consultation from Hirsh Cohen, and, in 2004, established the Bernstein Network Computational Neuroscience, named after the physiologist Julius Bernstein (1839–1917). The network initially had four centers in Berlin, Freiburg, Munich, and Göttingen and later expanded to two more in Heidelberg-Mannheim and Tübingen. The success of the Bernstein Network program put Germany on the map. Among the trainees who went on to professorships were Matthias Bethge (Max Planck Institute in Tübingen), Julijana Gjorgjieva (the Technical University of Munich), Christian Machens (Champalimaud in Lisbon, Portugal), Susanne Schreiber (Humboldt University of Berlin), and Tim Vogels (Austrian Institute of Science and Technology).

Susanne Schreiber, the current director of the Bernstein Network echoed many of us when she wrote:

I am a firm believer in interdisciplinary approaches that closely link theoretical considerations to (neuro)biology (and experiments where possible) and perhaps sometimes enable insights beyond the traditional field, for example for neuromorphic hardware and even artificial intelligence. I am a firm believer in heterogeneity of approaches and levels (both methodologically, from analytics to numerics to large-scale data analysis, as well as content-wise, from biophysics to cognition). I highly value scientific creativity, from non-mainstream [endeavors] and ideas of individuals to larger-scale collaborations where synergy is beneficial. I believe we need the opportunity for scientific exchange as well as a really inspiring learning environment for young researchers in the field. And finally, we all need to be internationally connected because science is at its most productive and also most fun if we can work with the people that are the best in their field (no matter their location) and whose interests and expertise best matches the questions we would like to address. Having said so, the Bernstein [Network] for me is a structure that one way or another seeks to support all these different aspects of research and that contributes to these goals, helping to create novel opportunities and enabling computational neuroscientists and their collaborators to do better work.

Upon reflection, the massive movement of talents from quantitative fields to neuroscience was unprecedented—perhaps unique—among disciplines in the life sciences. The Sloan Foundation spent \$14 million *in toto*. Over a period of 25 years, the Swartz Foundation generously gave about \$46 million (the program ended last year). The German government invested more than €100 million in the Bernstein Network. The CRCNS budget has been about \$10 million per year, on average,

since 2002. The total US government investment so far in computational neuroscience is difficult to estimate, but it is likely to be a tiny fraction of the overall budget for brain research, from \$4.2 billion in 2008 to \$10.5 billion in 2024, according to an analysis by *The Transmitter*. The impact has been enormous by any measure, amply justifying taxpayer dollars.

Progress in basic neuroscience paved the way for translational studies that benefit society at large. The Gatsby center in London and Swartz Center at Yale were among the first to promote the field of computational psychiatry that integrates basic research and clinical studies with the aim of building a solid biological foundation of mental healthcare.⁹ In artificial intelligence (AI) and brain-machine interfaces, two examples come to mind: former Sloan fellow Philip Sabes co-founded Neuralink, and former Swartz fellow Surya Ganguli was instrumental in the development of diffusion models of wide use in modern AI. Numerous young computational neuroscientists went on to make contributions at DeepMind, Google, Anthropic, OpenAI, Meta, etc., or to launch their own startups. The payoff of private and government investments is immeasurable.

What makes our field so exciting for young talent? For those who are not content with only abstract theory but want to connect with empirical observations, neuroscience offers a gold mine with a variety of big data. Moreover, the field is unusually cross-disciplinary and embraces researchers from diverse fields. As Eve Marder likes to say, “Hopefully we do science because of some intellectual joy it brings us, and the entire host of quantitatively skilled scientists who moved into computational neuroscience all did so because they felt the magic and challenge of trying to use their rigorous training to understand the mysteries of the brain.” We are all curious about our brains and minds. It must be intriguing for a “nerd” to realize that they can use mathematics to help understand how the brain works and uncover the biological explanations of consciousness, mathematics, music, and emotional feelings.

As we are entering a new era characterized by the advances of technologies and availability of multi-omic big data, theory

and modeling are poised to play a pivotal role in our endeavor to understand the brain basis of behavior and intelligence, as well as in mental health and the next generation of AI.¹⁰ The field is grateful to the visionary private citizens and leaders in the governments for their support, which ought to continue into the future.

ACKNOWLEDGMENTS

I would like to thank the Alfred P. Sloan Foundation, the Swartz Foundation, and the following individuals who generously provided information for this article: Larry Abbott, Tom Albright, Richard Andersen, Surya Ganguli, Dennis Glanzman, Mark Goldman, Andreas Herz, Steve Lisberger, Yuan Liu, Tom McKenna, Eve Marder, Bijan Pesaran, Susanne Schreiber, Terry Sejnowski, Bob Shapley, Eric Shea-Brown, and Alexandra Stein. This article is dedicated to all faculty and postdoctoral fellows at the former Sloan and Swartz Centers of Theoretical Neuroscience.

DECLARATION OF INTERESTS

The author declares no competing interests.

REFERENCES

1. Koch, C., and Segev, I. (1989). *Methods in Neuronal Modeling: From Synapses to Networks* (MIT Press). C. Koch and I. Segev.
2. Barlow, H.B. (1972). Single units and sensation: a neuron doctrine for perceptual psychology? *Perception* 1, 371–394.
3. Marder, E., and Calabrese, R.L. (1996). Principles of rhythmic motor pattern generation. *Physiol. Rev.* 76, 687–717.
4. Rumelhart, D.E., and McClelland, J.L.; PDP Research Group (1986). *Parallel Distributed Processing* (MIT Press).
5. Hopfield, J.J. (1982). Neural networks and physical systems with emergent collective computational abilities. *Proc. Natl. Acad. Sci. USA* 79, 2554–2558.
6. Sejnowski, T.J., Koch, C., and Churchland, P.S. (1988). Computational neuroscience. *Science* 241, 1299–1306.
7. Abbott, L.F., and Marder, E. (2022). Remembering Hirsh Cohen and His Role in Developing Computational Neuroscience. *eNeuro* 9, ENEURO.0284-22.2022.
8. Dayan, P., and Abbott, L.F. (2001). *Theoretical Neuroscience* (MIT Press).
9. Wang, X.-J., and Krystal, J.H. (2014). Computational Psychiatry. *Neuron* 84, 638–654.
10. Wang, X.-J. (2025). *Theoretical Neuroscience: Understanding Cognition* (Taylor & Francis/CRC Press).