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INNOVATORS & IDEAS: RISING STAR

Eric Sun: Understanding brain aging at spatial and single-cell resolution with machine learning

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Eric D. Sun illuminates the revolutionary intersection of machine learning and aging biology, which promises to transform our understanding of brain aging at an unprecedented single-cell resolution. Emerging from Stanford University's Biomedical Data Science program, Eric Sun is set to establish his independent laboratory at MIT's Department of Biological Engineering and the Ragon Institute in 2026. He represents the vanguard of computational scientists redefining aging research through innovative artificial intelligence approaches. His groundbreaking development of spatial aging clocks, sophisticated machine learning models capable of measuring biological age at the cellular level, has unveiled previously hidden mechanisms of brain aging, including the remarkable discovery of cell types that can dramatically influence the aging trajectory of neighboring cells in both pro-aging and pro-rejuvenating directions. This pioneering work, recently published in *Nature* (2025), bridges the gap between computational innovation and biological discovery, positioning Eric Sun at the forefront of a new era in aging research where machine learning not only decodes the complex biology of aging but also accelerates the discovery of targeted interventions against age-related diseases, including dementia. Through this compelling Genomic Press Interview, readers gain intimate insights into the scientific journey, philosophical perspectives, and ambitious vision of a rising star whose multidisciplinary approach promises to unlock the secrets of healthy brain aging and translate these discoveries into transformative therapeutics for humanity's most pressing age-related challenges.

Figure 1. Eric Sun, Stanford University, USA.

Part 1: Eric Sun – Life and Career Eric Sun

Could you give us a glimpse into your personal history, emphasizing the pivotal moments that first kindled your passion for science?

I spent a lot of my early childhood at the public library, which was a veritable goldmine when it came to learning about science. I started off being obsessed with dinosaurs and paleobiology and then transitioned to new interests in space exploration and astronomy—both of which I am still fond of today. Although I no longer intend to become a paleontologist nor an astrophysicist/astronomer, these early exposures to science were very formative in pushing me along the path toward a research career and kindling my current interests.

Growing up, math was my favorite subject through high school, and although it may not have directly sparked my passion for science, my early love for math shaped the research areas and approaches that I have been drawn to. For example, most of my research projects to date have been computational, and I find myself mainly attracted to systems or computational biology approaches for answering important research questions.

From high school through college, I also had the great fortune of gaining research experience under some exceptional mentors in the areas of computational biology and health. Given the computational nature of these early experiences, I was given considerable independence to lead my research projects. As such, I had the freedom to think, tinker, and explore at my leisure, and this made me fall in love with the process of scientific research and discovery. Altogether, these experiences encouraged me to consider a research career seriously.

Please share with us what initially piqued your interest in your favorite research or professional focus area.

I have always been fascinated with the biology of aging. Why do we get wrinkles when we get older? Why does it become harder to learn and easier to forget? How come some animals live substantially longer than others, yet seemingly all animals experience aging? These were some of the

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core questions that drove my early interest in aging. However, I never considered aging as a tractable area of scientific study until I came across a book (at the public library, of course) that included a chapter dedicated to Cynthia Kenyon's pioneering work on dramatically extending the lifespan of *C. elegans* (a small worm often studied in the lab). I was only in elementary school at the time, but the revelation that scientists could and were actively working out the biology of aging was terrific to me.

We would like to know more about your career trajectory leading up to your current role. What defining moments channeled you toward this opportunity?

I grew up in Pueblo, Colorado, and attended local public schools. In high school, I was fortunate to have had the opportunity to complete summer research projects both domestically and abroad. Since there were few opportunities to conduct research locally, these summer programs had a profoundly influential impact on my decision to pursue a career in science. During college, I studied Chemistry, Physics, and Applied Math at Harvard, where I quickly became involved in various research projects, ranging from simulating the evolution of chromosomes and the growth of fruits to building mathematical models of aging and utilizing machine learning to predict age from multi-omics data. These experiences helped me broaden my foundation in various scientific disciplines and enabled me to determine the research areas and approaches that best suited me. After college, I joined the Stanford Biomedical Informatics graduate program, where I focused on building computational and machine learning models for spatial and single-cell gene expression data, with several important applications in the context of brain aging. Next year, I will be starting my lab at the MIT Department of Biological Engineering as an Assistant Professor and a member of the Ragon Institute.

I look forward to defining my research program and mentoring the next generation of scientists.

What is a decision or choice that seemed like a mistake at the time but ended up being valuable or transformative for your career or life?

Initially, attending graduate school seemed like a mistake during my first year in the program, partly due to the remote start during the pandemic. Although classes and lectures were interesting, I did not feel the same spark of excitement for research that I had discovered as an undergraduate and that had motivated me to apply to graduate school. It was not until after I arrived on Stanford's campus during my second year that I realized the missing spark was the lack of interaction with the other graduate students, researchers, and faculty. Science is a community-driven endeavor, and having the opportunity to discuss ideas and experiments with other researchers is the single most important catalyst for scientific discovery. Since arriving on campus, I have found my dissertation research and the numerous scientific discussions and interactions that have stemmed from it to be incredibly rewarding and transformative for my career and outlook on science.

What habits and values did you develop during your academic studies or subsequent postdoctoral experiences that you uphold within your research environment?

In terms of habits, maintaining a daily schedule and a list of priority items is incredibly useful. I also maintain flexibility in my plans to accommodate unforeseen circumstances or opportunities that often arise during the research process. In terms of values, I place much emphasis on transparency and open science.

Please tell us more about your current scholarly focal points within your chosen field of science.

My research is primarily focused on developing computational and machine-learning methods to accelerate the progress of aging research, particularly in the areas of brain and immune aging. To do so, I am focusing on a few key steps. First, I am interested in building new machine-learning frameworks that can reliably measure aging at single-cell or even subcellular resolution. These types of models are commonly referred to as "aging clocks", models trained to predict age or an aging-related quantity from a large set of different measurements. Although aging clocks have been developed and applied in various contexts, there is still considerable room for improvement in these models to make reliable predictions for individual cells and multiple organs, as well as to account for underlying statistical assumptions. Second, I am interested in building large-scale AI models to predict the effects of multi-scale biological perturbations, such that, with some level of accuracy, one can forecast the effects that genetic or cellular perturbations will have on an organism. In the context of aging, these models would facilitate high-throughput computational screens for rejuvenating perturbations (i.e., perturbations that reverse the aging process), but they also have numerous potential applications in other areas of biomedical interest, such as immunotherapy, injury response, and neurodegeneration. Finally, I am interested in developing machine learning tools to efficiently search the complex parameter space for interventions, which includes parameters such as intensity, dosage, timing, and combinations, to identify the optimal interventions for counteracting aging in different organs. Altogether, my scholarly focus concerns building tools to measure aging, using these tools to predict the effects of perturbations on aging, and then leveraging this knowledge to transform these perturbations into optimal interventions against aging.

What impact do you hope to achieve in your field by focusing on specific research topics?

In the short term, I plan to build new computational tools and frameworks to reliably quantify aging across multiple biological scales (from subcellular to whole organism). Building on my recent *Nature* publication (2025, PMID: 39695234; DOI: 10.1038/s41586-024-08334-8), I plan to expand these spatial aging clock frameworks to other tissues and develop them as standard tools for the aging research community. These tools will be crucial in defining aging, which in turn will enable the screening of various interventions for their effects on biological aging. I hope that these tools can be readily applied by other researchers working on aging and age-associated diseases (e.g., dementia) to help inform their experiments or interpret their results. At the same time, I plan to develop machine learning models that can efficiently explore the intervention design space to suggest candidate interventions for combating aging. In the long term, I hope to translate some of these potential discoveries into effective therapeutics and address fundamental questions about the nature of aging and its underlying biological mechanisms.

Outside of my research, I am excited to establish my own lab and mentor students and postdoctoral researchers. I want to support and cultivate the next generation of scientists, both within the field of aging research and beyond.

What do you most enjoy in your capacity as an academic or research rising star?

I enjoy the freedom to explore and delve deeply into questions of broad importance to our understanding of health and disease. This academic freedom has been vital for studying biological processes, such as aging, which are incredibly complex and still not well-defined.

At Genomic Press, we prioritize fostering research endeavors based solely on their inherent merit, uninfluenced by geography or the researchers' personal or demographic traits. Are there particular cultural facets within the scientific community that warrant transformative scrutiny, or is there a cause within science that you feel strongly devoted to?

In the scientific community, there is often a strong cultural emphasis on "success" and perhaps less so on "failure," yet the latter is exceedingly more common than the former, and often, a string of failures is the catalyst for an eventual research discovery or success. This disparity in visibility between success and failure can be disheartening to students in their first research experiences. An important responsibility for scientific mentors will be to emphasize both the regularity and importance of failure in scientific discovery and career development, whether it manifests as inconclusive experiments, rejections for grant and fellowship applications, or manuscripts that were turned down. It will also be important to increase discussion on how researchers at all career stages can navigate and learn from failures in science.

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Figure 2. Eric enjoys natural views such as this sunset seen from a hiking trail near Stanford.

Outside professional confines, how do you prefer to allocate your leisure moments, or conversely, in what manner would you envision spending these moments given a choice?
I prioritize spending time with friends and family. In terms of pastimes, I generally prefer physical activities (e.g., hiking, working out, sports, etc.) since most of my professional work involves sitting in front of a computer. I also enjoy traveling, especially in the context of new places or experiences.

Where were you born and where do you live now?
I was born in Pueblo, Colorado. I currently live in Redwood City, California, but will be moving to Cambridge, Massachusetts in the coming year.

Part 2: Eric Sun – Selected questions from the Proust Questionnaire[1]

What is your most marked characteristic?
Adaptability.

Among your talents, which one(s) give(s) you a competitive edge?
Ideation, focus, resourcefulness.

If you could change one thing about yourself, what would it be?
Having the ability to function with minimal sleep.

What is your current state of mind?
I am happy and excited to start up some new research projects.

What is your idea of perfect happiness?
Unlimited and uninterrupted time to think.

When and where were you happiest? And why were so happy then?
I was happiest during my childhood because everything that I experienced or learned was completely new and exciting to me.

What is your greatest fear?
That there are challenges that cannot be overcome with effort or creativity.

What is your greatest regret?
I don't think it is productive to have regrets.

What are you most proud of?
Staying true to my principles.

What do you consider your greatest achievement?
Hopefully, my greatest achievement is yet to come.

What or who is your greatest passion?
Understanding the biological underpinnings of aging and developing approaches to restore health and function has been a driving focus of my interest in science since my earliest days.

[1]In the late nineteenth century, various questionnaires were a popular diversion designed to discover new things about old friends. What is now known as the 35-question Proust Questionnaire became famous after Marcel Proust's answers to these questions were found and published posthumously. Proust answered the questions twice, at ages 14 and 20. In 2003 Proust's handwritten answers were auctioned off for $130,000. Multiple other historical and contemporary figures have answered the Proust Questionnaire, including among others Karl Marx, Oscar Wilde, Arthur Conan Doyle, Fernando Pessoa, Stéphane Mallarmé, Paul Cézanne, Vladimir Nabokov, Kazuo Ishiguro, Catherine Deneuve, Sophia Loren, Gina Lollobrigida, Gloria Steinem, Pelé, Valentino, Yoko Ono, Elton John, Martin Scorsese, Pedro Almodóvar, Richard Branson, Jimmy Carter, David Chang, Spike Lee, Hugh Jackman, and Zendaya. The Proust Questionnaire is often used to interview celebrities: the idea is that by answering these questions, an individual will reveal his or her true nature. We have condensed the Proust Questionnaire by reducing the number of questions and slightly rewording some. These curated questions provide insights into the individual's inner world, ranging from notions of happiness and fear to aspirations and inspirations.

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What is your favorite occupation (or activity)?
I like going to the gym.

What is your greatest extravagance?
Sleeping in.

What is your most treasured possession?
My pet box turtle. Her name is Tooty.

Where would you most like to live?
For work: Cambridge, Massachusetts.
For leisure: Somewhere in the mountains with a great view.

What is the quality you most admire in people?
Courage.

What is the trait you most dislike in people?
Cowardice.

What do you consider the most overrated virtue?
Patience.

What do you most value in your friends?
Humor.

Which living person do you most admire?
Cynthia Kenyon. Her pioneering work on the genetics of aging is what inspired me to embark on a research career in this field.

Who are your heroes in real life?
My parents.

If you could have dinner with any historical figure, who would it be and why?
Isaac Newton. I would love to pick his brain on science and philosophy.

Who are your favorite writers?
Jules Verne and J.R.R. Tolkien.

Who are your heroes of fiction?
I have many heroes of fiction: Simba from *The Lion King*, Marlin from *Finding Nemo*, Fa Mulan from *Mulan*, Tadashi Hamada from *Big Hero 6*, Sirius Black from *Harry Potter*, Francie Nolan from *A Tree Grows in Brooklyn*, Luffy from *One Piece*, and Eren Jaeger from *Attack on Titan* are just some that come to mind.

What aphorism or motto best encapsulates your life philosophy?
Hakuna matata.

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Eric D. Sun[1]
[1]*Department of Biomedical Data Science, Stanford University, 290 Jane Stanford Way, Stanford, California 94305, USA*
✉ *e-mail: edsun@stanford.edu*

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