

BIOGRAPHICAL SKETCH

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NAME: Dhodapkar, Rahul Madhav

eRA COMMONS USER NAME (credential, e.g., agency login): RAHULDHODAPKAR

POSITION TITLE: Heed Fellowship

EDUCATION/TRAINING (*Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.*)

INSTITUTION AND LOCATION	DEGREE (if applicable)	Completion Date MM/YYYY	FIELD OF STUDY
Yale University	B.S.	05/2015	Computer Science
Yale University School of Medicine	M.D.	05/2023	Medicine
University of Southern California	Residency	06/2027	Ophthalmology

A. Personal Statement

I am an ophthalmology resident and early-stage physician-scientist with a background in computer science and a focus on developing and applying machine learning approaches to complex biomedical data. My research spans computational genomics, ophthalmic imaging, and digital health technologies, with the overarching goal of improving our understanding and clinical management of vision-threatening diseases. I have a particular interest in the application of artificial intelligence and machine learning to improve both diagnostics and management in ophthalmic pathology.

My prior work has centered on the development of novel computational frameworks for single-cell and molecular data analysis, including methods that leverage large language models to represent and interrogate cellular systems. These approaches enable cross-species translation, perturbation prediction, and identification of therapeutic targets, and are currently being applied to questions in retinal and optic nerve degeneration. This technology is also being applied outside of ophthalmology, to understand and design combinatorial chemotherapeutic and immunomodulatory regimens to treat resistant malignancies such as Merkel cell carcinoma.

Currently, my work includes applying machine learning techniques to develop new small molecule treatments for the regeneration of retinal ganglion cells from Müller glial cells in ex vivo human retina, using pathways identified through cross-species transcriptomic analysis. In parallel, I have continued to develop my expertise in multimodal ophthalmic imaging through the AI-READI training grant and research development program funded by the NIH, by developing new tools to predict ophthalmic retinal vascular complications from continuous glucose monitoring data. I have also expanded my work to develop several computer-vision enabled tools for strabismus measurement and real-time low vision assistance, to help bring some of the benefits of new developments in artificial intelligence directly into the clinical setting.

Through my clinical training and research, I aim to establish a career as a physician-scientist at the intersection of computational biology, ophthalmology, and digital health, with a focus on developing innovative, data-driven approaches to prevent and treat vision loss.

Ongoing projects/funding include:

Colton Center for Autoimmunity (Role: Co-I)

AI-Simulated *In Silico* Humans: A New Paradigm for Modeling Autoimmunity

NIH AIM-AHEAD Bridge2AI AI-READI Cohort 2 (Role: Trainee Grant Recipient)

B. Positions, Scientific Appointments, and Honors

Positions and Scientific Appointment

2023-current	Ophthalmology Resident, Roski Eye Institute, University of Southern California, Los Angeles, CA
2021-2022	Yale Center for Neuroinflammation Research Fellow, Yale University, New Haven, CT
2015-2018	Consulting Engineer, MongoDB, New York, NY

Honors

2026	AUPO Resident Research Forum Awardee
2026	AAPOS Fellow/Resident Research Award Finalist
2026	NANOS Resident Research Award Finalist
2022	Yale-Boehringer Ingelheim Datathon Winner
2022	Yale Department of Ophthalmology Award for Most Outstanding Research by a Medical Student
2021	Yale Department of Ophthalmology Award for Most Outstanding Research by a Medical Student
2022	Symposium on Artificial Intelligence for Learning Health Systems (SAIL) Travel Award
2018	Thrombosis and Hemostasis Societies of North America Travel Award

Professional Membership

2023-current	Member, American Academy of Ophthalmology (AAO)
2022-current	Member, Human Cell Atlas (HCA) Consortium
2021-current	Member, Association for Research in Vision and Ophthalmology (ARVO)

C. Contributions to Science

- 1. Applications of machine learning to single-cell transcriptomics:** One of my primary research interests is the development of new methods for the analysis of single-cell transcriptomic data based on cutting-edge techniques in the field of machine learning. One of these applications, Cell2Sentence, allows for direct interoperability between existing large language models such as GPT and single cell data in a seamless manner that allows for textual insight generation, cell state prediction, and cross species translation. We are now in the process of applying these tools to the development of new therapeutic targets for both neovascular and non-neovascular AMD through a grant from the Yale Colton Center for Autoimmunity, on which I am a co-investigator.
 - a. Dong M, Wang B, Wei J, Fonseca AH, Perry CJ, Frey A, Ouerghi F, Foxman EF*, Ishizuka JJ*, **Dhodapkar RM†**, van Dijk D† "Causal identification of single-cell experimental perturbation effects with CINEMA-OT." *Nature Methods* 20.11 (2023): 1769-1779. PMID: 37919419
 - b. **Dhodapkar RM**. Representing cells as sentences enables natural-language processing for single-cell transcriptomics. *bioRxiv*. 2022:2022-09.
 - c. Levine D, Lévy S, Rizvi SA, Pallikkavaliyaveetil N, Chen X, Zhang D, Ghadermarzi S, Wu R, Zheng Z, Vrkic I, Zhong A, Raskin D, Han I, Fonseca A, Caro JO, Karbasi A, **Dhodapkar RM†**, van Dijk D †. Cell2Sentence: Teaching Large Language Models the Language of Biology. *bioRxiv*. <https://doi.org/10.1101/2023.09.11.557287>
 - d. Rizvi S, Levine D, Patel A, Zhang S, Wang E, He S, Zhang D, Tang C, Lyu Z, Darji R, Li C, Sun E, Jeong D, Zhao L, Kwan J, Braun D, Hafler BP, Ishizuka J, **Dhodapkar RM**, Chung H, Azizi S, Perozzi B, van Dijk D. Scaling Large Language Models for Next-Generation Single-Cell Analysis. *bioRxiv*, <https://www.biorxiv.org/content/10.1101/2025.04.14.648850v1>
- 2. Understanding neuroinflammatory mechanisms in age-related macular degeneration:** Age-related macular degeneration (AMD) is a complex disease and a leading cause of blindness worldwide. Earlier in my career I was involved in several efforts to perform single-cell and single-nucleus RNA sequencing of human retina from donors with neovascular and non-neovascular AMD across varying stages of disease. Analysis of these data highlighted a key mediating role for microglia and

inflammatory signaling pathways in the pathophysiology of AMD, which is now becoming a better understood and widely accepted aspect of this disease.

- a. Kuchroo M, DiStasio M, Song E, Calapkulu E, Zhang L, Ige M, Sheth AH, Majdoubi A, Menon M, Tong A, Godavarthi A, Xing Y, Gigante S, Steach H, Huang J, Huguet G, Narain J, You K, Mourgkos G, **Dhodapkar RM**, Hirn MJ, Bastian R, Wolf G, Krishnaswamy S†, Hafler BP†. Single-cell analysis reveals inflammatory interactions driving macular degeneration. *Nature Communications*. 2023 Mar 5.
- b. **Dhodapkar RM**, Martell D, Hafler BP. Glial-mediated neuroinflammatory mechanisms in age-related macular degeneration. *Seminars in Immunopathology* 2022 Sep;44(5):673-683. doi: 10.1007/s00281-022-00939-3. Epub 2022 May 5. PMID: 35513496.
- c. Miller SJ, **Dhodapkar RM**, Sutova HE, Xue Y, Lee S, Logan R, Ran C, Bhatta S, Gomm A, Ju IG, Heyang M. SARS-CoV-2 induces Alzheimer's disease-related amyloid- β pathology in ex vivo human retinal explants and retinal organoids. *Science Advances*. 2025 Jul 4;11(27):eads5006.

3. Applications of computational methods to other clinical data: In addition to single-cell transcriptomics, I have a broad interest in the application of advanced computational techniques to various types of biomedical and clinical data, including imaging, proteomic, and patient-serological data. Of these efforts, a machine learning approach applied to identify serologic protein and antibody covariates associated with Long COVID was instrumental in highlighting the involvement of cortisol in this disease. These insights were instrumental in the design and implementation of the PAX LC trial, a Phase 2 double-blind trial studying the effect of antiviral therapy on persistent symptoms following SARS-CoV2 infection.

- a. Klein J*, Wood J*, Jaycox J*, **Dhodapkar RM***, Lu P*, Gelhausen JR*, Tabachnikova A*, Greene K, Tabacof L, Malik AA, Monteiro VS, Silva J, Kamath K, Zhang M, Dahl A, Ott I, Valle G, Pena-Hernandez M, Mao T, Bhattacharjee B, Takahashi T, Lucas C, Song E, Mccarthy D, Breyman E, Tosto-Mancuso J, Dai Y, Perotti E, Akduman K, Tzeng TJ, Xu L, Geraghty AC, Monje M, Yildirim I, Shon J, Medzhitov R, Lutchmansingh D, Possick J, Kaminski N, Omer SB, Krumholz HM, Guan L, Dela Cruz CS, van Dijk D†, Ring AM†, Putrino D†, Iwasaki A†. Distinguishing features of Long COVID identified through immune profiling. *Nature*. 2023 Nov 2;623(7985):139-48.
- b. **Dhodapkar RM**, Li E, Nwanyanwu K, Adelman R, Krishnaswamy S, Wang JC. Deep learning for quality assessment of optical coherence tomography angiography images. *Scientific Reports*. 2022 Aug 12;12(1):13775.
- c. **Dhodapkar RM**. A survey-wide association study to identify youth-specific correlates of major depressive episodes. *PloS One*. 2020 May 8;15(5):e0232373.
- d. **Dhodapkar RM**. A deep generative model of the SARS-CoV-2 spike protein predicts future variants. *bioRxiv*. 2023:2023-01.

4. Other clinical reports in ophthalmology: As a resident physician in ophthalmology, I am dedicated to contributing to the clinical literature throughout the field. During my training, I have published several cases and extended analyses regarding a range of ophthalmic pathologies.

- a. Gary AA, **Dhodapkar RM**, Lim S, Saber MS, Zhang-Nunes S. Case Report: Improvement from no light perception after radiotherapy and surgical debulking for orbital Rosai-Dorfman disease. *Frontiers in Ophthalmology*. 2025 Dec 11;5:1710976.
- b. **Dhodapkar RM**, Spadaro JZ, Adelman RA. A case of extrafoveal focal choroidal excavation. *American Journal of Ophthalmology Case Reports*. 2022 Sep 1;27:101682.
- c. **Dhodapkar RM**, Spadaro JZ, Heng JS, Sinard JH, Lee YH, Habib LA, Pointdujour-Lim R. NK/T-cell Lymphoma With Orbital Involvement: A Case Report and Systematic Review of the Literature. *Ophthalmic Plastic & Reconstructive Surgery*. 2023 Jan 24:10-97.

Full list of publications:

<https://orcid.org/0000-0002-2014-7515>