

Stanford

Paul Salomon Mischel

Professor of Pathology

 NIH Biosketch available Online

CONTACT INFORMATION

- **Alternate Contact**

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Bio

BIO

I am a physician scientist trained in pathology and cancer biology. My research bridges cancer genetics, signal transduction and cellular metabolism as we aim to understand the molecular mechanisms that drive cancer development, progression, and drug resistance. We have made a series of discoveries that have identified a central role for ecDNA (extrachromosomal DNA) in cancer development, progression, accelerated tumor evolution and drug resistance. These findings have provided a new understanding of the fundamental mechanisms of oncogene amplification and the spatial organization of altered tumor genomes, launching a new area of cancer research that links circular architecture with tumor pathogenesis. We have developed and applied a set of state of the art genetic, biochemical, computational, and advanced cell imaging tools to decipher the structure of circular ecDNA in cancer to a well-curated, large set of deeply characterized, ecDNA+ cancer models, revealing enhanced chromatin accessibility and the physical formation of new cis-regulatory interactions that lead to massive oncogene transcription and tumor progression. My lab has also uncovered metabolic co-dependencies that are downstream consequences of oncogene amplification. These include a central role for altered biochemical mechanisms that regulate oncogene copy number and function. These discoveries have resulted in new understandings of some of the fundamental processes by which oncogene amplification drives cancer progression and drug resistance in the changing environments within which tumors develop.

ACADEMIC APPOINTMENTS

- Professor, Pathology
- Member, Stanford Cancer Institute
- Institute Scholar, Stanford ChEM-H

ADMINISTRATIVE APPOINTMENTS

- Professor of Pathology, Stanford University School of Medicine, (2021- present)
- Vice Chair for Research, Department of Pathology, Stanford University School of Medicine, (2021- present)
- Institute Scholar, ChEM-H, Stanford University, (2021- present)

HONORS AND AWARDS

- Elected Fellow, American Association for the Advancement of Science (2015)
- Elected Member, American Association of Physicians (2012-present)
- President, American Society for Clinical Investigation (2010-2011)
- Elected Member, American Society for Clinical Investigation (2007-present)

- American's Top Doctors for Cancer, Castle & Connelly (2006-2021)
- Americas Top Doctors for Pathology, Castle & Connelly (2006-2021)
- Farber Award for Brain Cancer Research, American Association of Neurological Surgeons and the Society for Neuro-Oncology (2004)
- Pfizer New Faculty Scholar, Pfizer (1996)
- Alpha Omega Alpha, AOA (1991)

BOARDS, ADVISORY COMMITTEES, PROFESSIONAL ORGANIZATIONS

- Co-Founder and Chair of Scientific Advisory Board, Boundless Bio, Inc. (2018 - present)

PROFESSIONAL EDUCATION

- Post-Doctoral Fellowship, HHMI-UCSF (mentored by Dr. Louis Reichardt) , Molecular Neuroscience (1998)
- Residency, UCLA , Pathology and Neuropathology (1996)
- M.D., Cornell University Medical College (Weill Cornell) , Medicine (1991)
- B.A., University of Pennsylvania , Philosophy (1984)

LINKS

- My lab website: <https://med.stanford.edu/paulmischellab.html>
- My wikipedia page: https://en.wikipedia.org/wiki/Paul_Mischel
- My google scholar profile: <https://scholar.google.com/citations?user=IvSY4O8AAAAJ&hl=en>
- <https://chemh.stanford.edu/person/paul-mischel>: My ChEM-H page
- My pubmed link: <https://pubmed.ncbi.nlm.nih.gov/?term=mischel+p&sort=date>

Research & Scholarship

CURRENT RESEARCH AND SCHOLARLY INTERESTS

Human genes are arranged on 23 pairs of chromosomes, but in cancer, tumour-promoting genes can free themselves from chromosomes and relocate to circular, extrachromosomal pieces of DNA (ecDNA). These ecDNA don't follow the normal "rules" of chromosomal inheritance, enabling tumours to achieve far higher levels of cancer-causing oncogenes than would otherwise be possible, and licensing cancers with a way to evolve and change their genomes to evade treatments, at rates that would be unthinkable for human cells. The altered circular architecture of ecDNAs also changes the way that the cancer-causing genes are regulated and expressed, further contributing to aggressive tumor growth. These unique features make ecDNA-containing cancers especially aggressive and difficult to treat and cancer patients whose tumours harbour ecDNA have markedly shorter survival.

Despite being first seen over fifty years, ago, and prescient work on its potential importance, the scale, scope, and impact of ecDNA was not well understood. In fact, it was thought to be a rare event of unknown significance. The application of powerful new, integrative molecular approaches has shown us, that ecDNAs are present in nearly half of all human cancer types and at likely in at least a quarter of all cancer patients and they have taught us that ecDNA is indeed, one of the most urgent problems facing patients with cancer, challenging the success of the targeted therapy approaches, and a problem that is certainly worthy of its nomination as a Cancer Grant Challenge. Currently, the collective current understanding of how ecDNA form, how they move around the cell, how they evolve to resist treatment, how they impact the immune system, and how they can be effectively targeted, are lacking. Can we identify actionable co-dependency pathways that are generated by ecDNA amplification? These are the areas of research focus of research in my laboratory.

We are very collaborative and interactive, with many colleagues around the world. We work very closely with Professor Howard Chang at Stanford, as well as with many other new Stanford colleagues. I have recently joined the faculty of Stanford University as a Professor and Vice Chair for Research for the Department of

Pathology, and as an Institute Scholar in ChEM-H, where my lab is based. I am committed to actively contributing not only to the science and its translation for benefit to patients, but also to mentoring trainees at all levels, and helping colleagues, including junior colleagues, develop the skills necessary to navigate the complex landscape of translating science into medicines that will help patients.

Teaching

STANFORD ADVISEES

Doctoral Dissertation Reader (AC)

Valentino Sudaryo

Postdoctoral Faculty Sponsor

Jun Tang, Ivy Tsz-Lo Wong

Doctoral Dissertation Advisor (AC)

Caterina Colon

Publications

PUBLICATIONS

- **ecDNA hubs drive cooperative intermolecular oncogene expression.** *Nature*
Hung, K. L., Yost, K. E., Xie, L., Shi, Q., Helmsauer, K., Luebeck, J., Schopflin, R., Lange, J. T., Chamorro Gonzalez, R., Weiser, N. E., Chen, C., Valieva, M. E., Wong, et al
2021
- **Extrachromosomal DNA: An Emerging Hallmark in Human Cancer.** *Annual review of pathology*
Wu, S., Bafna, V., Chang, H. Y., Mischel, P. S.
2021
- **Targeting glioblastoma signaling and metabolism with a re-purposed brain-penetrant drug.** *Cell reports*
Bi, J., Khan, A., Tang, J., Armando, A. M., Wu, S., Zhang, W., Gimple, R. C., Reed, A., Jing, H., Koga, T., Wong, I. T., Gu, Y., Miki, et al
2021; 37 (5): 109957
- **Loss of polycomb repressive complex 1 activity and chromosomal instability drive uveal melanoma progression.** *Nature communications*
Bakhoun, M. F., Francis, J. H., Agustinus, A., Earlie, E. M., Di Bona, M., Abramson, D. H., Duran, M., Masilionis, I., Molina, E., Shoushtari, A. N., Goldbaum, M. H., Mischel, P. S., Bakhoun, et al
2021; 12 (1): 5402
- **CANCER'S EXTRA GENOME SCIENTIST**
Mischel, P.
2021; 35 (2): 32–38
- **Extrachromosomal DNA is associated with oncogene amplification and poor outcome across multiple cancers.** *Nature genetics*
Kim, H., Nguyen, N., Turner, K., Wu, S., Gujar, A. D., Luebeck, J., Liu, J., Deshpande, V., Rajkumar, U., Namburi, S., Amin, S. B., Yi, E., Menghi, et al
2020
- **Altered cellular metabolism in gliomas - an emerging landscape of actionable co-dependency targets.** *Nature reviews. Cancer*
Bi, J. n., Chowdhry, S. n., Wu, S. n., Zhang, W. n., Masui, K. n., Mischel, P. S.
2020; 20 (1): 57–70
- **Circular ecDNA promotes accessible chromatin and high oncogene expression.** *Nature*
Wu, S., Turner, K. M., Nguyen, N., Raviram, R., Erb, M., Santini, J., Luebeck, J., Rajkumar, U., Diao, Y., Li, B., Zhang, W., Jameson, N., Corces, et al
2019
- **Oncogene Amplification in Growth Factor Signaling Pathways Renders Cancers Dependent on Membrane Lipid Remodeling.** *Cell metabolism*
Bi, J., Ichu, T., Zanca, C., Yang, H., Zhang, W., Gu, Y., Chowdhry, S., Reed, A., Ikegami, S., Turner, K. M., Zhang, W., Villa, G. R., Wu, et al

2019

- **NAD metabolic dependency in cancer is shaped by gene amplification and enhancer remodelling.** *Nature*
Chowdhry, S. n., Zanca, C. n., Rajkumar, U. n., Koga, T. n., Diao, Y. n., Raviram, R. n., Liu, F. n., Turner, K. n., Yang, H. n., Brunk, E. n., Bi, J. n., Furnari, F. n., Bafna, et al
2019; 569 (7757): 570–75
- **Extrachromosomal oncogene amplification in tumour pathogenesis and evolution.** *Nature reviews. Cancer*
Verhaak, R. G., Bafna, V. n., Mischel, P. S.
2019; 19 (5): 283–88
- **Extrachromosomal oncogene amplification drives tumour evolution and genetic heterogeneity** *NATURE*
Turner, K. M., Deshpande, V., Beyter, D., Koga, T., Rusert, J., Lee, C., Li, B., Arden, K., Ren, B., Nathanson, D. A., Kornblum, H. I., Taylor, M. D., Kaushal, et al
2017; 543 (7643): 122+
- **An LXR-Cholesterol Axis Creates a Metabolic Co-Dependency for Brain Cancers** *CANCER CELL*
Villa, G. R., Hulce, J. J., Zanca, C., Bi, J., Ikegami, S., Cahill, G. L., Gu, Y., Lum, K. M., Masui, K., Yang, H., Rong, X., Hong, C., Turner, et al
2016; 30 (5): 683-693
- **Targeted therapy resistance mediated by dynamic regulation of extrachromosomal mutant EGFR DNA.** *Science (New York, N.Y.)*
Nathanson, D. A., Gini, B. n., Mottahedeh, J. n., Visnyei, K. n., Koga, T. n., Gomez, G. n., Eskin, A. n., Hwang, K. n., Wang, J. n., Masui, K. n., Paucar, A. n., Yang, H. n., Ohashi, et al
2014; 343 (6166): 72–76

PRESENTATIONS

- Location, location, location— the role of extrachromosomal DNA (ecDNA) in cancer - Department of Pathology, Stanford University School of Medicine (April 27, 2021)