Stanford

Nirao Shah

Professor of Psychiatry and Behavioral Sciences (Major Laboratories and Clinical Translational Neurosciences Incubator), of Neurobiology and, by courtesy, of Obstetrics and Gynecology

Bio

BIO

Dr. Nirao Shah is a Professor of Psychiatry and Behavioral Sciences and of Neurobiology at Stanford University. After completing his medical training, Nirao was a graduate student at Caltech, where he identified mechanisms that control differentiation of stem cells that give rise to the peripheral nervous system. For his post-graduate fellowship at Columbia University, Nirao developed genetic approaches to identify neural pathways that regulate social behaviors. In his own laboratory, his research has elaborated on such approaches to identify genes and neurons that control different aspects of social interactions. Nirao's findings have provided insights into how our brains enable social interactions in health, and they are relevant to understanding mechanisms underlying behavioral manifestations of autism, dementia, mood disorders, and PTSD.

ACADEMIC APPOINTMENTS

- Professor, Psychiatry and Behavioral Sciences
- Professor, Neurobiology
- Professor (By courtesy), Obstetrics & Gynecology
- Member, Bio-X
- Faculty Fellow, Sarafan ChEM-H
- Member, Wu Tsai Neurosciences Institute

ADMINISTRATIVE APPOINTMENTS

- Director of Neurosciences Graduate Program, School of Medicine, (2019- present)

HONORS AND AWARDS

- Scholar in Neuroscience, Ellison Medical Foundation (2012)
- Byers Award, UCSF (2010)
- Pioneer Award, NIH (2009)
- Young Investigator Award, NARSAD (2009)
- Mallinckrodt Scholar, Edward Mallinckrodt, Jr. Foundation (2008)
- Kavli Fellow, German American Frontiers of Science Foundation (2006)
- Alfred P. Sloan Fellow, Sloan Foundation (2005)
- Scholar, McKnight Endowment Fund for Neuroscience (2005)
- Career Award in Biomedical Sciences, Burroughs Wellcome Fund (2000)
- Fellow, Jane Coffin Childs Memorial Fund for Medical Research (1997)

PROFESSIONAL EDUCATION

- Fellow, Columbia University , Neural Circuits & Behavior (2003)
- Ph.D., Caltech , Stem Cells (1997)
- Clinical Internship, Seth G.S. Medical College & K.EM. Hospital, Mumbai , Medicine (1991)
- M.B.,B.S., Seth G.S. Medical College & K.EM. Hospital, Mumbai , Medicine (1990)

PATENTS

- David Anderson, Nirao Shah. "United States Patent 6,001,654 Methods for differentiating neural stem cells to neurons or smooth muscle cells using TGF-ß super family growth factors", Caltech, Dec 14, 1999

LINKS

- Nirao Shah's Lab Website: http://med.stanford.edu/nirao.html

Research & Scholarship

CURRENT RESEARCH AND SCHOLARLY INTERESTS

We study how our brains generate social interactions that differ between the sexes. Such gender differences in behavior are regulated by sex hormones, experience, and social cues. Accordingly, we are characterizing how these internal and external factors control gene expression and neuronal physiology in the two sexes to generate behavior. We are also interested in understanding how such sex differences in the healthy brain translate to sex differences in many neuro-psychiatric illnesses.

Teaching

STANFORD ADVISEES

Doctoral Dissertation Reader (AC)

Lucas Encarnacion-Rivera, Josh Head, Qilin Zhao

Postdoctoral Faculty Sponsor

Lele Cui, Biswadeep Khan, Ai Miyasaka, Sakura Tanaka, Renzhi Yang

GRADUATE AND FELLOWSHIP PROGRAM AFFILIATIONS

- Endocrinology (Fellowship Program)
- Neurosciences (PhD Program)

Publications

PUBLICATIONS

- **A neural circuit for male sexual behavior and reward.** *Cell*
  Bayless, D. W., Davis, C. O., Yang, R., Wei, Y., de Andrade Carvalho, V. M., Knoedler, J. R., Yang, T., Livingston, O., Lomvardas, A., Martins, G. J., Vicente, A. M., Ding, J. B., Luo, et al
  2023
- **Hypothalamic neurons that mirror aggression.** *Cell*
  Yang, T., Bayless, D. W., Wei, Y., Landayan, D., Marcelo, I. M., Wang, Y., DeNardo, L. A., Luo, L., Druckmann, S., Shah, N. M.
  2023
- **Oxytocin receptor is not required for social attachment in prairie voles.** *Neuron*
  Berendzen, K. M., Sharma, R., Mandujano, M. A., Wei, Y., Rogers, F. D., Simmons, T. C., Seelke, A. M., Bond, J. M., Larios, R., Goodwin, N. L., Sherman, M., Parthasarthy, S., Espineda, et al

2022

- **A functional cellular framework for sex and estrous cycle-dependent gene expression and behavior.** *Cell*
  Knoedler, J. R., Inoue, S., Bayless, D. W., Yang, T., Tantry, A., Davis, C., Leung, N. Y., Parthasarathy, S., Wang, G., Alvarado, M., Rizvi, A. H., Fenno, L. E., Ramakrishnan, et al
  1800

- **Periodic Remodeling in a Neural Circuit Governs Timing of Female Sexual Behavior.** *Cell*
  Inoue, S., Yang, R., Tantry, A., Davis, C., Yang, T., Knoedler, J. R., Wei, Y., Adams, E. L., Thombare, S., Golf, S. R., Neve, R. L., Tessier-Lavigne, M., Ding, et al
  2019

- **Evolution of Mechanisms that Control Mating in Drosophila Males.** *Cell reports*
  Ahmed, O. M., Avila-Herrera, A., Tun, K. M., Serpa, P. H., Peng, J., Parthasarathy, S., Knapp, J., Stern, D. L., Davis, G. W., Pollard, K. S., Shah, N. M.
  2019; 27 (9): 2527

- **Limbic Neurons Shape Sex Recognition and Social Behavior in Sexually Naive Males.** *Cell*
  Bayless, D. W., Yang, T., Mason, M. M., Susanto, A. A., Lobdell, A., Shah, N. M.
  2019

- **Neural control of sexually dimorphic social behaviors** *CURRENT OPINION IN PHYSIOLOGY*
  McKinsey, G. L., Ahmed, O. M., Shah, N. M.
  2018; 6: 89–95

- **Molecular mechanisms underlying sexual differentiation of the nervous system.** *Current opinion in neurobiology*
  Knoedler, J. R., Shah, N. M.
  2018; 53: 192–97

- **Identification of a motor-to-auditory pathway important for vocal learning.** *Nature neuroscience*
  Roberts, T. F., Hisey, E., Tanaka, M., Kearney, M. G., Chattree, G., Yang, C. F., Shah, N. M., Mooney, R.
  2017

- **Social Control of Hypothalamus-Mediated Male Aggression.** *Neuron*
  Yang, T. n., Yang, C. F., Chizari, M. D., Maheswaranathan, N. n., Burke, K. J., Borius, M. n., Inoue, S. n., Chiang, M. C., Bender, K. J., Ganguli, S. n., Shah, N. M.
  2017; 95 (4): 955–70.e4

- **Molecular and neural control of sexually dimorphic social behaviors** *CURRENT OPINION IN NEUROBIOLOGY*
  Yang, T., Shah, N. M.
  2016; 38: 89-95

- **Retinofugal Projections from Melanopsin-Expressing Retinal Ganglion Cells Revealed by Intraocular Injections of Cre-Dependent Virus** *PLOS ONE*
  Delwig, A., Larsen, D. D., Yasumura, D., Yang, C. F., Shah, N. M., Copenhagen, D. R.
  2016; 11 (2)

- **Genetic dissection of neural circuits underlying sexually dimorphic social behaviours** *PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B-BIOLOGICAL SCIENCES*
  Bayless, D. W., Shah, N. M.
  2016; 371 (1688)

- **Sex-dependent changes in metabolism and behavior, as well as reduced anxiety after eliminating ventromedial hypothalamus excitatory output** *MOLECULAR METABOLISM*
  Cheung, C. C., Krause, W. C., Edwards, R. H., Yang, C. F., Shah, N. M., Hnasko, T. S., Ingraham, H. A.
  2015; 4 (11): 857-866

- **Specification of Select Hypothalamic Circuits and Innate Behaviors by the Embryonic Patterning Gene Dbx1** *NEURON*
  Sokolowski, K., Esumi, S., Hirata, T., Kamal, Y., Tuyen Tran, T., Lam, A., Oboti, L., Brighthaupt, S., Zaghlula, M., Martinez, J., Ghimbovschi, S., Knoblach, S., Pierani, et al
  2015; 86 (2): 403-416

- **Medial Amygdalar Aromatase Neurons Regulate Aggression in Both Sexes** *CELL REPORTS*
  Unger, E. K., Burke, K. J., Yang, C. F., Bender, K. J., Fuller, P. M., Shah, N. M.
  2015; 10 (4): 453-462
- **Representing Sex in the Brain, One Module at a Time** *NEURON*
  Yang, C. F., Shah, N. M.
  2014; 82 (2): 261-278
- **Striatal Cholinergic Interneurons Drive GABA Release from Dopamine Terminals** *NEURON*
  Nelson, A. B., Hammack, N., Yang, C. F., Shah, N. M., Seal, R. P., Kreitzer, A. C.
  2014; 82 (1): 63-70
- **Complex Chemosensory Control of Female Reproductive Behaviors** *PLOS ONE*
  Fraser, E. J., Shah, N. M.
  2014; 9 (2)
- **Turning ON Caspases with Genetics and Small Molecules** *REGULATED CELL DEATH PT A: APOPTOTIC MECHANISMS*
  Morgan, C. W., Julien, O., Unger, E. K., Shah, N. M., Wells, J. A.
  2014; 544: 179-213
- **Genetic and Neural Mechanisms that Inhibit Drosophila from Mating with Other Species** *CELL*
  Fan, P., Manoli, D. S., Ahmed, O. M., Chen, Y., Agarwal, N., Kwong, S., Cai, A. G., Neitz, J., Renslo, A., Baker, B. S., Shah, N. M.
  2013; 154 (1): 89-102
- **Neural control of sexually dimorphic behaviors** *CURRENT OPINION IN NEUROBIOLOGY*
  Manoli, D. S., Fan, P., Fraser, E. J., Shah, N. M.
  2013; 23 (3): 330-338
- **Sexually Dimorphic Neurons in the Ventromedial Hypothalamus Govern Mating in Both Sexes and Aggression in Males** *CELL*
  Yang, C. F., Chiang, M. C., Gray, D. C., Prabhakaran, M., Alvarado, M., Juntti, S. A., Unger, E. K., Wells, J. A., Shah, N. M.
  2013; 153 (4): 896-909
- **Generation of Induced Pluripotent Stem Cells from the Prairie Vole** *PLOS ONE*
  Manoli, D. S., Subramanyam, D., Carey, C., Sudin, E., van Westerhuyzen, J. A., Bales, K. L., Blelloch, R., Shah, N. M.
  2012; 7 (5)
- **Modular Genetic Control of Sexually Dimorphic Behaviors** *CELL*
  Xu, X., Coats, J. K., Yang, C. F., Wang, A., Ahmed, O. M., Alvarado, M., Izumi, T., Shah, N. M.
  2012; 148 (3): 596-607
- **Restriction of Transient Receptor Potential Vanilloid-1 to the Peptidergic Subset of Primary Afferent Neurons Follows Its Developmental Downregulation in Nonpeptidergic Neurons** *JOURNAL OF NEUROSCIENCE*
  Cavanaugh, D. J., Chesler, A. T., Braz, J. M., Shah, N. M., Julius, D., Basbaum, A. I.
  2011; 31 (28): 10119-10127
- **Trpv1 Reporter Mice Reveal Highly Restricted Brain Distribution and Functional Expression in Arteriolar Smooth Muscle Cells** *JOURNAL OF NEUROSCIENCE*
  Cavanaugh, D. J., Chesler, A. T., Jackson, A. C., Sigal, Y. M., Yamanaka, H., Grant, R., O'Donnell, D., NiColl, R. A., Shah, N. M., Julius, D., Basbaum, A. I.
  2011; 31 (13): 5067-5077
- **Control of masculinization of the brain and behavior** *CURRENT OPINION IN NEUROBIOLOGY*
  Wu, M. V., Shah, N. M.
  2011; 21 (1): 116-123
- **The Androgen Receptor Governs the Execution, but Not Programming, of Male Sexual and Territorial Behaviors** *NEURON*
  Juntti, S. A., Tollkuhn, J., Wu, M. V., Fraser, E. J., Soderborg, T., Tan, S., Honda, S., Harada, N., Shah, N. M.
  2010; 66 (2): 260-272
- **Estrogen Masculinizes Neural Pathways and Sex-Specific Behaviors** *CELL*

Wu, M. V., Manoli, D. S., Fraser, E. J., Coats, J. K., Tollkuhn, J., Honda, S., Harada, N., Shah, N. M.
2009; 139 (1): 61-72

- **A genetic approach to dissect sexually dimorphic behaviors** *HORMONES AND BEHAVIOR*
  Juntti, S. A., Coats, J. K., Shah, N. M.
  2008; 53 (5): 627-637
- **Abnormal social behaviors in mice lacking Fgf17** *GENES BRAIN AND BEHAVIOR*
  Scearce-Levie, K., Roberson, E. D., Gerstein, H., Cholfin, J. A., Mandiyan, V. S., Shah, N. M., Rubenstein, J. L., Mucke, L.
  2008; 7 (3): 344-354
- **Behavioural neurobiology - Females can also be from Mars** *NATURE*
  Shah, N. M., Breedlove, S. M.
  2007; 448 (7157): 999-1000
- **Nursing behavior: Remembrance of things past** *CURRENT BIOLOGY*
  Shah, N. M.
  2006; 16 (19): R842-R844
- **Deficits in sexual and aggressive behaviors in Cnga2 mutant mice** *NATURE NEUROSCIENCE*
  Mandiyan, V. S., Coats, J. K., Shah, N. M.
  2005; 8 (12): 1660-1662
- **Visualizing sexual dimorphism in the brain** *NEURON*
  Shah, N. M., Pisapia, D. J., Maniatis, S., Mendelsohn, M. M., Nemes, A., Axel, R.
  2004; 43 (3): 313-319
- **Integration of multiple instructive cues by neural crest stem cells reveals cell-intrinsic biases in relative growth factor responsiveness** *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA*
  Shah, N. M., ANDERSON, D. J.
  1997; 94 (21): 11369-11374
- **Regulatory mechanisms in stem cell biology** *CELL*
  Morrison, S. J., Shah, N. M., ANDERSON, D. J.
  1997; 88 (3): 287-298
- **Cell lineage determination and the control of neuronal identity in the neural crest** *COLD SPRING HARBOR SYMPOSIA ON QUANTITATIVE BIOLOGY*
  ANDERSON, D. J., Groves, A., Lo, L., Ma, Q., Rao, M., Shah, N. M., Sommer, L.
  1997; 62: 493-504
- **Alternative neural crest cell fates are instructively promoted by TGF beta superfamily members** *CELL*
  Shah, N. M., Groves, A. K., ANDERSON, D. J.
  1996; 85 (3): 331-343
- **The cellular function of MASH1 in autonomic neurogenesis** *NEURON*
  Sommer, L., Shah, N., Rao, M., ANDERSON, D. J.
  1995; 15 (6): 1245-1258
- **GLIAL GROWTH-FACTOR RESTRICTS MAMMALIAN NEURAL CREST STEM-CELLS TO A GLIAL FATE** *CELL*
  Shah, N. M., Marchionni, M. A., Isaacs, I., Stroobant, P., ANDERSON, D. J.
  1994; 77 (3): 349-360