

# Nathan C. Shaner

## Curriculum vitae

University of California, San Diego  
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### **EDUCATION**

1999            B.A. Physics, with highest honors, Oberlin College, Oberlin, OH  
2006            Ph.D. Biomedical Sciences, University of California, San Diego, La Jolla, CA  
                  Advisor: Roger Y. Tsien

### **POSITIONS AND EMPLOYMENT**

2019 - present      Associate Adj. Professor, Neurosciences, UC San Diego, La Jolla, CA  
2018 - 2019        Academic Program Management Officer, UC San Diego, La Jolla, CA  
2016 - 2019        Associate Professor, Scintillon Institute  
2012 - 2016        Assistant Professor, Scintillon Institute  
2008 - 2012        Post Doc, Monterey Bay Aquarium Research Institute, Moss Landing, CA  
                  Advisor: Steven Haddock  
2006 - 2008        Post Doc, Salk Institute for Biological Studies, La Jolla, CA  
                  Advisors: Joanne Chory and Joseph Noel  
2006 - present     Director of Translational Research  
                  Allele Biotechnology & Pharmaceuticals, Inc.

### **FELLOWSHIPS, AWARDS, AND HONORS**

2007 - 2010        Helen Hay Whitney Postdoctoral Fellowship  
2007 -2008        Salk Institute Innovation Grant  
                  (with Joanne Chory and Joseph Noel)  
2003 - 2006        Howard Hughes Medical Institute Predoctoral Fellowship  
2003                National Science Foundation Graduate Research Fellowship

**PUBLICATIONS** (h-index: 24, total citations: 12,679 (via Google Scholar))

**Peer-reviewed:**

Drobizhev M., Molina R.S., Callis P.R., Scott J.N., Lambert G.G., Salih A., **Shaner N.C.**, & Hughes T.E. (2021) Local Electric Field Controls Fluorescence Quantum Yield of Red and Far-Red Fluorescent Proteins. *Front. Mol. Biosci.* (accepted, in press).

Lambert G.G., Depernet H., Gotthard G., Schultz D.T., Navizet I., Lambert T., Adams S.R., Torreblanca-Zanca A., Chu M., Bindels D.S., Levesque V., Nero Moffatt J., Salih A., Royant A., & **Shaner N.C.** (2020) Aequorea's secrets revealed: New fluorescent proteins with unique properties for bioimaging and biosensing. *PLoS Biol.* Nov 2;18(11):e3000936.

de Heuvel E., Singh A.K., Boronat P., Kooistra A.J., van der Meer T., Sadek P., Blaazer A.R., **Shaner N.C.**, Bindels D.S., Caljon G., Maes L., Sterk G.J., Siderius M., Oberholzer M., de Esch I.J.P., Brown D.G., & Leurs R. (2019) Alkynamide phthalazinones as a new class of TbrPDEB1 inhibitors (Part 2). *Bioorg Med Chem.* Sep 15;27(18):4013-4029.

Tewson P., Martinka S., **Shaner N.C.**, Berlot C., Quinn A.M., & Hughes T. (2018) Assay for Detecting Gai-Mediated Decreases in cAMP in Living Cells. *SLAS Discov.* Jul 1: 2472555218786238.

Hong S.R., Wang C.L., Huang Y.S., Chang Y.C., Chang Y.C., Pusapati G.V., Lin C.Y., Hsu N., Cheng H.C., Chiang Y.C., Huang W.E., **Shaner N.C.**, Rohatgi R., Inoue T., & Lin Y.C. (2018) Spatiotemporal manipulation of ciliary glutamylation reveals its roles in intraciliary trafficking and Hedgehog signaling. *Nat Commun.* Apr 30;9(1):1732.

Mastop M., Bindels D.S., **Shaner N.C.**, Postma M., Gadella T.W.J. Jr., & Goedhart J. (2017) Characterization of a spectrally diverse set of fluorescent proteins as FRET acceptors for mTurquoise2. *Sci Rep.* Sep 20;7(1):11999.

Molina R.S., Tran T.M., Campbell R.E., Lambert G.G., Salih A., **Shaner N.C.**, Hughes T.E., & Drobizhev M. (2017) Blue-Shifted Green Fluorescent Protein Homologues Are Brighter than Enhanced Green Fluorescent Protein under Two-Photon Excitation. *J Phys Chem Lett.* Jun 15;8(12):2548-2554.

Shen Y., Chen Y., Wu J., **Shaner N.C.**, & Campbell R.E. (2017) Engineering of mCherry variants with long Stokes shift, red-shifted fluorescence, and low cytotoxicity. *PLoS One.* 2017 Feb 27;12(2):e0171257.

Clavel D., Gotthard G., von Stetten D., de Sanctis D., Pasquier H., Lambert G.G., **Shaner N.C.**, & Royant A. (2016) Structural analysis of the bright monomeric yellow-green fluorescent protein mNeonGreen obtained by directed evolution. *Acta Crystallographica D Struct Biol,* 72(12):1298-1307.

Tewson P.H., Martinka S., **Shaner N.C.**, Hughes T.E., & Quinn A.M. (2016) New DAG and cAMP Sensors Optimized for Live-Cell Assays in Automated Laboratories. *J Biomol Screen*, 21(3):298-305.

Francis W.R., **Shaner N.C.**, Christianson L.M., Powers M.L., & Haddock S.H. (2015) Occurrence of Isopenicillin-N-Synthase Homologs in Bioluminescent Ctenophores and Implications for Coelenterazine Biosynthesis. *PLoS One*, 10(6):e0128742.

**Shaner, N.C.**, Lambert, G.G., Chammas, A., Ni, Y., Cranfill, P.J., Baird, M.A., Sell, B.R., Allen, J.R., Day, R.N., Davidson, M.W., & Wang, J. (2013) A bright monomeric green fluorescent protein derived from *Branchiostoma lanceolatum*. *Nature Methods*, 10(5), 407-9.

Francis, W.R., Christianson, L.M., Kiko, R., Powers, M.L., **Shaner, N.C.**, & Haddock, S.H. (2013) A comparison across non-model animals suggests an optimal sequencing depth for de novo transcriptome assembly. *BMC Genomics*, 14(1):167.

Powers, M.L., McDermott, A.G., **Shaner, N.C.**, & Haddock, S.H. (2012) Expression and characterization of the calcium-activated photoprotein from the ctenophore *Bathocyroe fosteri*: Insights into light-sensitive photoproteins. *Biochemical and Biophysical Research Communications*, 431(2):360-6.

Li, H., Foss, S.M., Dobryy, Y., Park, C.K., Hires, S.A., **Shaner, N.C.**, Tsien, R.Y., Osborne, L.C. & Voglmaier, S.M. (2011) Concurrent imaging of synaptic vesicle recycling and calcium dynamics. *Frontiers in Molecular Neuroscience*, 4:34.

Siebert, S., Robinson, M.D., Tintori, S., Goetz, F., Helm, R. Smith, S.A., **Shaner, N.C.**, Haddock, S.H.D. & Dunn, C.W. (2011) Differential gene expression in the siphonophore *Nanomia bijuga* (Cnidaria) assessed with multiple next-generation sequencing workflows. *PLoS One*, 6(7):e22853.

Ewen-Campen, B., **Shaner, N.C.**, Panfilio, K.A., Suzuki, Y., Roth, S. & Extavour, C.G. (2011) The maternal and early embryonic transcriptome of the milkweed bug *Oncopeltus fasciatus*. *BMC Genomics*, 12:61.

Hoi, H., **Shaner, N.C.**, Davidson, M.W., Cairo, C.W., Wang, J. & Campbell, R.E. (2010) A monomeric photoconvertible fluorescent protein for imaging of dynamic protein localization. *Journal of Molecular Biology*, 401(5), 776-91.

Ouyang, M., Huang, H., **Shaner, N.C.**, Remacle, A.G., Shiryayev, S.A., Strongin, A.Y., Tsien, R.Y. & Wang, Y. (2010) Simultaneous visualization of pro-tumorigenic Src and MT1-MMP activities with fluorescence resonance energy transfer. *Cancer Research*, 70(6), 2204-12.

Lin, M.Z., McKeown, M.R., Ng, H.L., Aguilera, T.A., **Shaner, N.C.**, Campbell, R.E., Adams, S.R., Gross, L.A., Ma, W., Alber, T. & Tsien, R.Y. (2009) Autofluorescent proteins with

excitation in the optical window for intravital imaging in mammals. *Chemistry & Biology*, 16(11), 1169-79.

**Shaner, N.C.**, Lin, M.Z., McKeown, M.R., Steinbach, P.A., Hazelwood, K.L., Davidson, M.W. & Tsien, R.Y. (2008) Improving the photostability of bright monomeric orange and red fluorescent proteins. *Nature Methods*, 5(6), 545-51.

**Shaner, N.C.**, Patterson, G.H. & Davidson, M.W. (2007) Advances in fluorescent protein technology. *Journal of Cell Science*, 120(Pt 24) 4247-60.

Shu, X., **Shaner, N.C.**, Yarbrough, C.A., Tsien, R.Y. & Remington, S.J. (2006) Novel chromophores and buried charges control color in mFruits. *Biochemistry*, 45(32), 9639-47.

Ai, H.W., **Shaner, N.C.**, Cheng, Z., Tsien, R.Y. & Campbell, R.E. (2007) Exploration of new chromophore structures leads to the identification of improved blue fluorescent proteins. *Biochemistry*, 46(20), 5904-10.

**Shaner, N.C.**, Steinbach, P.A. & Tsien, R.Y. (2005) A guide to choosing fluorescent proteins. *Nature Methods*, 2(12), 905-9.

Wang, J., **Shaner, N.C.**, Mittal, B., Zhou, Q., Chen, J., Sanger, J.M. & Sanger, J.W. (2005) Dynamics of Z-band based proteins in developing skeletal muscle cells. *Cell Motility and the Cytoskeleton*, 61(1), 34-48.

**Shaner, N.C.**, Sanger, J.W. & Sanger, J.M. (2005) Actin and alpha-actinin dynamics in the adhesion and motility of EPEC and EHEC on host cells. *Cell Motility and the Cytoskeleton*, 60(2), 104-20.

**Shaner, N.C.**, Campbell, R.E., Steinbach, P.A., Giepmans, B.N., Palmer, A.E. & Tsien R.Y. (2004) Improved monomeric red, orange and yellow fluorescent proteins derived from *Discosoma* sp. red fluorescent protein. *Nature Biotechnology*, 22(12), 1567-72.

Sanger, J.W., Chowrashi, P., **Shaner, N.C.**, Spalthoff, S., Wang, J., Freeman, N.L. & Sanger, J.M. (2002) Myofibrillogenesis in skeletal muscle cells. *Clinical Orthopaedics and Related Research*, 403 Suppl, S153-62.

Ayoob, J.C., **Shaner, N.C.**, Sanger, J.W. & Sanger, J.M. (2001) Expression of green or red fluorescent protein (GFP or DsRed) linked proteins in nonmuscle and muscle cells. *Molecular Biotechnology*, 17(1), 65-71.

### **Book chapters and editorial contributions:**

Fujita K., Nagai T., **Shaner N.C.**, Egnér A. (2016) Special Section Guest Editorial: Protein Photonics for Imaging, Sensing, and Manipulation: Honoring Prof. Osamu Shimomura, a Pioneer of Photonics for Biomedical Research. *J Biomed Opt*, 20(10): 101201.

**Shaner, N.C.** (2014) “Development of new colors from coral fluorescent proteins” in *The Fluorescent Protein Revolution* (Taylor & Francis Group)

**Shaner, N.C.** (2014) “Fluorescent Proteins for Quantitative Microscopy: Important Properties and Practical Evaluation” in *Methods in Cell Biology: Quantitative Imaging in Cell Biology* (Elsevier)

**Shaner, N.C.** (2014) “Green Fluorescent Protein (GFP)” in *eLS* (John Wiley & Sons Ltd)

**Shaner, N.C.** (2013) The mFruit collection of monomeric fluorescent proteins. *Clin Chem*, 2013 59(2):440-1.

**Preprints (non-peer reviewed):**

Celinskis D., Friedman N., Koksharov M., Murphy J., Gomez-Ramirez M., Borton D., **Shaner N.C.**, Hochgeschwender U., Lipscombe D., and Moore C. Miniaturized Devices for Bioluminescence Imaging in Freely Behaving Animals. bioRxiv 152546. June 15, 2020.

Raghuram A., Ye F., Adams J.K., **Shaner N.C.**, Robinson J., and Veeraraghavan A. Determining the Depth Limit of Bioluminescent Sources in Scattering Media. bioRxiv 044892. April 23, 2020.

Lambert G.G., Depernet H., Gotthard G., Schultz D.T., Navizet I., Lambert T., Bindels D.S., Levesque V., Moffatt J.N., Salih A., Royant A., **Shaner N.C.** *Aequorea victoria*'s secrets. bioRxiv 677344. June 28, 2019.

## **RESEARCH GRANTS**

### **Active Funding**

2014 - 2021

“Fluorescent proteins for superresolution imaging”

R01 GM109984, National Institute of General Medical Sciences (NIGMS)

**Shaner, NC** (PI)

Role: PI

Annual Direct Costs: \$190,000

2017 - 2021

“Probes for Luminescence-based Superresolution Microscopy”

R01 GM121944, National Institute of General Medical Sciences (NIGMS)

**Shaner, NC** (PI)

Role: PI

Annual Direct Costs: \$197,500

2017 - 2022

“Neurotechnology Hub: Bioluminescence for Optimal Brain Control and Imaging”

1707352, National Science Foundation (BRAIN Initiative)

Moore, CI (PI)

Role: Co-PI

Annual Direct Costs to Shaner: \$243,000

2019 - 2021

“Highly specific control of neurons with photoswitchable bioluminescent optogenetics”

R21 EY030716, National Eye Institute (NEI) (BRAIN Initiative)

Shaner, NC (PI); Hochgeschwender, U (Co-PI); Moore, CI (Co-PI)

Role: PI

Annual direct costs to Shaner: \$100,000

2019 - 2022

“Designing novel indicators for multiphoton voltage imaging”

U01 NS113294, National Institute of Neurological Disorders and Stroke (NINDS) (BRAIN Initiative)

Tolias, AS (PI); St-Pierre, F (PI)

Role: Co-PI

Annual direct costs to Shaner: \$121,020

2020 - 2023

“From seaside to bedside: evolution of bioluminescent genetically encoded Neurotransmitter Indicators and activators for neuromodulation”

2027113, National Science Foundation (BRAIN Initiative)

Gilad, A. (PI)

Role: Co-PI

Annual direct costs to Shaner: \$20,000

## **Completed Funding**

2016 - 2020

“BioLuminescent OptoGenetics (BL-OG): A Novel and Versatile Strategy for Neuromodulation”

U01 NS099709, National Institute of Neurological Disorders and Stroke (NINDS) (BRAIN Initiative)

Hochgeschwender, U (PI); Moore, CI (PI); Shaner, NC (PI)

Role: PI

2017 - 2018

“IBIS: Implantable bioluminescence interface system for an all-optical neuroprosthesis to the visual cortex”

DARPA-16-09-NESD-FP-014

Pieribone, VA (PI)

Role: Co-PI

2014 - 2017

“BRAIN EAGER: Genetically Encoded Light Sources for Non-Invasive Optogenetics”

1464686, National Science Foundation

Hochgeschwender, Ute H. (PI)

Role: Co-PI

2014 - 2015

“Nano-Antibodies for Studying RNA Modifications”

1R43DA038978-01, NIH (NIDA)

Wang, Jiwu (PI)

Role: Co-Investigator

2014 - 2014

“RNA-Guided Gene Targeting in Human Cells”

1R43GM106537-01A1, NIH (NIGMS)

Wang, Jiwu (PI)

Role: Co-Investigator



## **SELECTION OF INVITED TALKS**

- 2019 US-Japan Workshop on Bioengineering & Information Science, UC San Diego,  
La Jolla, CA
- 2019 Johns Hopkins University, Department of Biological Chemistry, Baltimore, MD
- 2019 Quantitative Imaging: From Acquisition to Analysis  
Cold Spring Harbor Laboratory, NY
- 2018 Quantitative Imaging: From Acquisition to Analysis  
Cold Spring Harbor Laboratory, NY
- 2017 Quantitative Imaging: From Cells to Molecules  
Cold Spring Harbor Laboratory, NY
- 2016 HHMI/Janelia Farm Fluorescent Proteins and Biological Sensors V
- 2016 Brown University  
Department of Neuroscience. Providence, RI
- 2016 Northwestern University  
Department of Biochemistry and Molecular Genetics, Chicago, IL
- 2016 Quantitative Imaging: From Cells to Molecules  
Cold Spring Harbor Laboratory, NY
- 2015 Western Sydney University, Sydney, NSW Australia
- 2015 Quantitative Imaging: From Cells to Molecules  
Cold Spring Harbor Laboratory, NY
- 2014 HHMI/Janelia Farm Fluorescent Proteins and Biological Sensors IV
- 2009 SPIE Biomedical Optics Symposium
- 2006 American Society for Photobiology 33rd Meeting

## **PROFESSIONAL MEMBERSHIPS AND OTHER ACTIVITIES**

- 2020 - present      Member, Cell Signaling San Diego Leadership Team
- 2018                  Symposium Organizer, “Next Generation Technologies for Neuroscience,” Brown University, Providence, RI
- 2018 - 2019        Course Instructor, “NeuroNex Practicum on Bioluminescence,” Marine Biological Laboratory, Woods Hole, MA
- 2016 - present     Member, Society for Neuroscience
- 2016 - present     Member, American Chemical Society
- 2016 - present     Member, Biophysical Society
- 2015 - present     Member, American Society for Cell Biology
- 2015                  Guest Editor, Journal of Biomedical Optics
- 2015                  Symposium Organizer, “Cells, Sensors, & Systems,” Scintillon Institute, San Diego, CA
- 2008 - 2009        Program committee member, Biomedical Optics Symposium “Fluorescent in vivo imaging based on genetically engineered probes: from living cells up to small animal whole body imaging IV” SPIE 2009 Conference, San Jose, CA
- 2005 - 2008        Co-founder, BioBridge educational outreach program University of California, San Diego (now known as ScienceBridge; URL: [sciencebridge.ucsd.edu](http://sciencebridge.ucsd.edu))
- 2014 - present     Summer undergraduate and high school student research mentor

## **PATENTS**

Campbell, R.E., **Shaner, N.C.**, & Tsien, R.Y. Monomeric and dimeric fluorescent protein variants and methods for making same. University of California, San Diego (issued US Patent 7,687,614)

Tsien, R.Y., Campbell, R.E., & **Shaner, N.C.** Monomeric and dimeric fluorescent protein variants and methods for making same. University of California, San Diego (issued US Patent 7,906,636)

Wang, J., Campbell, R.E., Hoi, H., & **Shaner, N.C.** Photoconvertible fluorescent proteins. University of Alberta, Edmonton and Allele Biotechnology & Pharmaceuticals (issued US Patent 9,145,447B2)

**Shaner, N.C.**, Lambert G., & Wang, J. Monomeric yellow-green fluorescent protein from cephalochordate. Allele Biotechnology & Pharmaceuticals Inc. (Issued US Patent 10,221,221B2)

**Shaner, N.C.**, Lin, M.Z., McKeown, M., & Tsien, R.Y. Fluorescent proteins with increased photostability. University of California, San Diego (US Patent Application No. 20090203035)

Wang, J., Lambert, G.G., & **Shaner, N.C.** Methods of selecting antibodies and antibody fragments. Allele Biotechnology & Pharmaceuticals Inc. (US Patent Application No. 20170044608A1)

**Shaner, N.C.** & Lambert, G.G. New bright green fluorescent proteins (provisional US/World application, title TBD, UCSD)