

Jeremy Nathans

Current Position:

Professor

Department of Molecular Biology and Genetics

Department of Neuroscience

Samuel Theobald Professor, Wilmer Eye Institute (Department of Ophthalmology)

Johns Hopkins University School of Medicine

Investigator

Howard Hughes Medical Institute

Personal Data:

Born July 31, 1958; New York City

Married to Thanh Huynh. Children: Riva (born 7/88) and Rosalie (born 3/94)

Business Address:

805 PCTB

Department of Molecular Biology and Genetics

Johns Hopkins University School of Medicine

725 North Wolfe Street

Baltimore, MD 21205

tel: 410-955-4679

FAX: 410-614-0827

e-mail: jnathans@jhmi.edu

Education:

Massachusetts Institute of Technology

B.S., Life Sciences

1979

B.S., Chemistry

1979

Stanford University School of Medicine

Ph.D., Biochemistry (with David Hogness)

1985

M.D.

1987

Postdoctoral fellow, Genentech, Inc.

(with Axel Ullrich)

1987

Professional Experience:

Assistant Professor, Department of Molecular Biology and Genetics,

Department of Neuroscience, Johns Hopkins University School of Medicine

Assistant Investigator, Howard Hughes Medical Institute

1988–1992

Associate Professor, Department of Molecular Biology and Genetics,

Department of Neuroscience, Johns Hopkins University School of Medicine

Associate Investigator, Howard Hughes Medical Institute

1992-1996

Associate Professor, Department of Ophthalmology

Johns Hopkins University School of Medicine

1993-1996

Professor, Department of Molecular Biology and Genetics,

Department of Neuroscience, Department of Ophthalmology	1996-present
Johns Hopkins University School of Medicine	1997-present
Investigator, Howard Hughes Medical Institute	

Advisory and Grant Review Boards (past):

Scientific Advisory Board, Zanvil Kreiger Mind–Brain Institute, J.H.U.	1991-1992
Scientific Advisory Board, The Ruth and Milton Steinbach Fund	1997-2007
Intramural Program Review Committee, National Eye Institute, N.I.H.	1997-1998
Grant Review Board, McKnight Endowment Fund for Neuroscience	2000-2011
Scientific Advisory Board for Ophthalmology, Novartis	2005-2008
Visiting Committee, Division of Medical Sciences, Harvard Medical School	2006-2010
Grant Review Board, HHMI International Scholars Program	2006, 2011
Scientific Advisory Committee, Machiah Foundation	2009-2011
Grant Review Board, HHMI Professors Program	2010
Scientific Advisory Board, Merck Research Laboratories	1996-1999 and 2008-2013
Grant Review Board, Beckman Initiative for Macular Research	2010-2014

Advisory and Grant Review Boards (current):

Scientific Advisory Board, The Foundation Fighting Blindness	1995-present
Grant Review Board, Life Sciences Research Foundation	2005-present
Advisor, HHMI Janelia Farm Research Campus	2009-present
Grant Review Board, Klingenstein/Simons Fellowship Awards in Neuroscience	2013-present
Scientific Advisory Board, Blue Cone Monochromacy Families Foundation	2014-present

Honors and Awards:

John Asinari Award for undergraduate research in the life sciences, M.I.T.	1978
Alpha Chi Sigma Award for excellence in chemistry, M.I.T.	1979
Newcomb–Cleveland Prize, American Association for the Advancement of Science	1986
Young Scientist Award, Passano Foundation	1987
Initiatives in Research Award, National Academy of Sciences, U.S.A.	1987
Rank Prize in Opto–Electronics, Rank Prize Fund (London)	1988
Wilson S. Stone Memorial Award, M.D. Anderson Cancer Center	1988
Distinguished Young Scientist Award, Maryland Academy of Sciences	1989
Golden Brain Award, Minerva Foundation	1989
Cogan Award, The Association for Research in Vision and Ophthalmology	1992
Alcon Research Institute Award for Vision Research, Alcon Laboratories	1992
Young Investigator Award, Society for Neuroscience	1995
Member, National Academy of Sciences, U.S.A.	1996
Member, American Academy of Arts and Sciences	2000
Teacher of the Year, Graduate Student Association, Johns Hopkins Medical School	2003, 2010, 2016
Professor’s Award for Distinction in Teaching in the Basic Sciences, Johns Hopkins Medical School	2004
Golden Apple Award for Teaching Excellence, American Medical Student Association	2004
Champalimaud Award for Vision Research (shared with King-Wai Yau)	2008
Fellow, American Association for the Advancement of Science	2009
Edward Scolnick Prize in Neuroscience, McGovern Institute, MIT	2009
Member, National Academy of Medicine (formerly, Institute of Medicine), U.S.A.	2011
Albert Muse Prize, The Eye and Ear Foundation of Pittsburgh	2012
Gilman Scholar, Johns Hopkins University	2013
Arthur Kornberg and Paul Berg Lifetime Achievement Award in Biomedical Sciences, Stanford Medical School	2013
Member, American Association of Physicians	2014
Beckman-Argyros Award in Vision Research, Arnold and Mabel Beckman Foundation	2016

Editorial Positions:

Associate Editor, Journal of Neuroscience	1991-1996
Editorial Board Member, Proceedings of the National Academy of Sciences, U.S.A.	1999-present
Associate Editor, Proceedings of the National Academy of Sciences, U.S.A.	2005-2006
Board of Reviewing Editors, eLife	2012-present

Award Committees:

Award Committee, Passano Award, Passano Foundation	2004-present
Award Committee, Molecular Biology Award, National Academy of Sciences, U.S.A.	2004
Award Committee, Lasker Prizes, Albert and Mary Lasker Foundation	2010-present

Named or Honorary Lectures:

Juan March Lecture, Juan March Foundation, Madrid	1991
W.S. Stiles Lecture, University College, London	1992
Walter Sondheim Lecture, Columbus Center, Baltimore	1996
Jack Schultz Memorial Lecture, Fox Chase Cancer Center, Philadelphia	1996
Holiday Lectures (with A. J. Hudspeth), Howard Hughes Medical Institute	1997
Zacharias Dische Memorial Lecture, Columbia University	2001
Stephen M. Schuetze Memorial Lecture, Columbia University	2002
Keynote Lecture, FASEB Meeting – Biology and Chemistry of Vision	2003
Rachford Lecture, Cincinnati Children's Hospital Research Foundation	2004
Russell DeValois Memorial Lecture, University of California, Berkeley	2007
Laureate Lecture, University of Pittsburgh	2008
Edward Scolnick Prize Lecture in Neuroscience, McGovern Institute, MIT	2009
Gordon Guroff Memorial Lecture, NIH	2009
George Khoury Memorial Lecture, NIH	2010
Friedman Lecture, Mount Sinai Medical School	2012
Muse Prize Lecture, University of Pittsburgh	2012
Marvin Sears Lecture, Yale University	2012
Edward R. and Anne G. Leffler Lecture, Harvard Medical School	2013
Dialogues of Discovery Lecture, Janelia Farm Research Campus, HHMI	2014
The C.H. Li Memorial Lectures, University of California, Berkeley	2014
Randy Chipperfield Memorial Lecture, M.I.T.	2015
Eric Shooter Lecture, Stanford Medical School	2015
Harvey Lecture, The Harvey Society	2016

Web materials:

Holiday Lectures (with A. J. Hudspeth), Howard Hughes Medical Institute	1997
The Vertebrate Retina (four lectures), iBioSeminars, ASCB/HHMI	2008
Creativity in Science, iBioMagazine, ASCB/HHMI	2011
One Amazing Second in the Life of Your Brain (lecture), iBiology, ASCB/HHMI	2011
Advice for Young Scientists, Lasker Lessons in Leadership, NIH	2016

Patents:

1. United States Patents Nos. 5,693,775 (issued 12/2/97) and 5,872,226 (issued 2/16/99). Fibroblast growth factor homologous factor-1 (FHF-1) and methods of use. Inventors: Nathans, J., Smallwood, P.M., and Macke, J.P.
2. United States Patent No. 5,876,967 (issued 3/2/99). Fibroblast growth factor homologous factor-2 (FHF-2) and methods of use. Inventors: Nathans, J., Smallwood, P.M., and Macke, J.P.

3. United States Patent No. 6,020,189 (issued 2/1/00) Fibroblast growth factor homologous factors (FHF) and methods of use. Inventors: Nathans, J. and Smallwood, P.M.
4. United States Patent No. 6,635,744 (issued 10/21/03) Fibroblast growth factor homologous factor-4 (FHF-4). Inventors: Nathans, J. and Smallwood, P.M.
5. United States Patents Nos. 6,713,300 (issued 3/30/04) and 7,141,420 (issued 11/28/06). Nucleic acid and amino acid sequences for ATP-binding cassette transporter and methods of screening for agents that modify ATP-binding cassette transporter. Inventors: Allikmets, R., Singh, N., Sun, H., Shroyer, N.F., Hutchinson, A., Chidambaram, A., Gerrard, B., Baird, I., Stauffer, D., Peiffer, A., Rattner, A., Smallwood, P., Li, Y., Anderson, K.L., Lewis, R.A., Nathans, J., Leppert, M., Dean, M. and Lupski, J.R.
6. United States Patents No. 8129353 (issued 3/6/12). Methods of gene therapy using nucleic acid sequences for ATP-binding cassette transporter. Inventors: Allikmets, R., Anderson, K.L., Dean, M., Leppert, M., Lewis, R.A., Li, Y., Lupski, J.R., Nathans, J., Rattner, A., Shroyer, N., Singh, N., Smallwood, P., and Sun, H.

Publications:

Research Publications:

1. Wang, A., Nathans, J., Van Der Marel, G., Van Boom, J.H., and Rich, A. (1978) Molecular structure of a double helical DNA fragment intercalator complex between deoxy CpG and a terpyridine platinum compound. *Nature* 276: 471–474.
2. Kronenberg, H.M., McDevitt, B.E., Majzoub, J.A., Nathans, J., Sharp, P., Potts, J.T., and Rich, A. (1979) Cloning and nucleotide sequence of DNA coding for bovine preproparathyroid hormone. *Proceedings of the National Academy of Sciences USA* 76: 4981–4986.
3. Nathans, J. and Hogness, D.S. (1983) Isolation, sequence analysis, and intron–exon arrangement of the gene encoding bovine rhodopsin. *Cell* 34: 807–814.
4. Nathans, J. and Hogness, D.S. (1984) Isolation and nucleotide sequence of the gene encoding human rhodopsin. *Proceedings of the National Academy of Sciences USA* 81: 4851–4855.
5. Nathans, J., Thomas, D., and Hogness, D.S. (1986) Molecular genetics of human color vision: the genes encoding blue, green, and red pigments. *Science* 232: 193–202.
6. Nathans, J., Piantanida, T.P., Eddy, R.L., Shows, T.B., and Hogness, D.S. (1986) Molecular genetics of inherited variation in human color vision. *Science* 232: 203–210.
7. Vollrath, D., Nathans, J., and Davis, R.W. (1988) Tandem array of human visual pigment genes at Xq28. *Science* 240: 1669–1671.
8. Nathans, J., Weitz, C.J., Agarwal, N., Nir, I., and Papermaster, D.S. (1989) Production of bovine rhodopsin by mammalian cell lines expressing cloned cDNA: spectrophotometry and subcellular localization. *Vision Research* 29: 907–914.
9. Nathans, J., Davenport, C.M., Maumenee, I.H., Lewis, R.A., Hejtmancik, J.F., Litt, M., Lovrien, E., Weleber, R., Bachynski, B., Zwas, F., Klingaman, R., and Fishman, G. (1989) Molecular genetics of human blue cone monochromacy. *Science* 245: 831–838.
10. Nathans, J. (1990) Determinants of visual pigment absorbance: the role of charged amino acids in the putative transmembrane segments. *Biochemistry* 29: 937–942.

11. Nathans, J. (1990) Determinants of visual pigment absorbance: identification of the retinylidene Schiff's base counterion in bovine rhodopsin. *Biochemistry* 29: 9746–9752.
12. Zack, D.J., Bennett, J., Wang, Y., Davenport, C., Klaunberg, B., Gearhart, J., and Nathans, J. (1991) Unusual topography of bovine rhodopsin promoter–lacZ fusion gene expression in transgenic mouse retinas. *Neuron* 6: 187–199.
13. Sung, C.–H., Davenport, C.M., Hennessey, J.C., Maumenee, I.H., Jacobson, S.G., Heckenlively, J.R., Nowakowski, R., Fishman, G., Gouras, P., and Nathans, J. (1991) Rhodopsin mutations in autosomal dominant retinitis pigmentosa. *Proceedings of the National Academy of Sciences USA* 88: 6481–6485.
14. Sung, C.–H., Schneider, B.G., Agarwal, N., Papermaster, D.S., and Nathans, J. (1991) Functional heterogeneity of mutant rhodopsins responsible for autosomal dominant retinitis pigmentosa. *Proceedings of the National Academy of Sciences USA* 88: 8840–8844.
15. Jacobson, S.G., Kemp, C.M., Sung, C.–H., and Nathans, J. (1991) Retinal function and rhodopsin levels in autosomal dominant retinitis pigmentosa with rhodopsin mutations. *American Journal of Ophthalmology* 112: 256–271.
16. Weitz, C.J., Miyake, Y., Shinzato, K., Montag, E., Zrenner, E., Went, L.N., and Nathans, J. (1992) Human tritanopia associated with two amino acid substitutions in the blue–sensitive opsin. *American Journal of Human Genetics* 50: 498–507.
17. Kemp, C.M., Jacobson, S.G., Roman, A.J., Sung, C.–H., and Nathans, J. (1992) Abnormal rod dark adaptation in autosomal dominant retinitis pigmentosa with proline–23–histidine rhodopsin mutation. *American Journal of Ophthalmology* 113: 165–174.
18. Merbs, S.L., and Nathans, J. (1992) Absorption spectra of human cone pigments. *Nature* 356: 433–435.
19. Weitz, C.J., and Nathans, J. (1992) Histidine residues regulate the transition of photoexcited rhodopsin to its active conformation, metarhodopsin II. *Neuron* 8: 465–472.
20. Wang, S.–Z., Adler, R., and Nathans, J. (1992) A visual pigment from chicken that resembles rhodopsin: amino acid sequence, gene structure, and functional expression. *Biochemistry* 31: 3309–3315.
21. Dhallan, R.S., Macke, J., Eddy, R.L., Shows, T.B., Reed, R.R., Yau, K.–W., and Nathans, J. (1992) Human rod photoreceptor cGMP-gated channel: amino acid sequence, gene structure, and functional expression. *Journal of Neuroscience* 12: 3248–3256.
22. Weitz, C.J., Went, L.N., and Nathans, J. (1992) Human tritanopia associated with a third amino acid substitution in the blue sensitive visual pigment gene. *American Journal of Human Genetics* 51: 444–446.
23. Merbs, S.L., and Nathans, J. (1992) Photobleaching difference absorption spectra of human cone pigments: quantitative analysis and comparison to other methods. *Photochemistry and Photobiology* 56: 869–881.
24. Wang, Y., Macke, J. P., Merbs, S. L., Klaunberg, B., Bennett, J., Zack, D., Gearhart, J., and Nathans, J. (1992) A locus control region adjacent to the human red and green pigment genes. *Neuron* 9: 429–440.
25. Merbs, S.L., and Nathans, J. (1992) Absorption spectra of the hybrid pigments responsible for anomalous color vision. *Science* 258: 464–466.

26. Borjigin, J., and Nathans, J. (1993) Bovine pancreatic trypsin inhibitor (BPTI) - trypsin complex as a detection system for recombinant proteins. *Proceedings of the National Academy of Sciences USA* 90: 337-341.
27. Johnson, R.L., Grant, K.B., Zankel, T.C., Boehm, M.F., Merbs, S.L., Nathans, J., and Nakanishi, K. (1993) Cloning and expression of goldfish opsin sequences. *Biochemistry* 32: 208-214.
28. Macke, J.P., Davenport, C.M., Jacobson, S.G., Hennessey, J.C., Gonzalez-Fernandez, F., Conway, B.P., Heckenlively, J., Palmer, R., Maumenee, I.H., Sieving, P., Gouras, P., Good, W., and Nathans, J. (1993) Identification of novel rhodopsin mutations responsible for retinitis pigmentosa: implications for the structure and function of rhodopsin. *American Journal of Human Genetics* 53: 80-89.
29. Macke, J. P., Hu, N., Hu, S., Bailey, M., King, V.L., Brown, T., Hamer, D., and Nathans, J. (1993) Sequence variation in the androgen receptor gene is not a common determinant of male sexual orientation. *American Journal of Human Genetics* 53: 844-852.
30. Merbs, S. L., and Nathans, J. (1993) Role of hydroxyl-bearing amino acids in differentially tuning the absorption spectra of the human red and green cone pigments. *Photochemistry and Photobiology* 58: 706-710.
31. Nathans, J., Maumenee, I.H., Zrenner, E., Sadowski, B., Sharpe, L.T., Lewis, R.A., Hansen, E., Rosenberg, T., Schwartz, M., Heckenlively, J.R., Traboulsi, E., Klingaman, R., Bech-Hansen, N.T., LaRoche, G.R., Pagon, R.A., Murphey, W.H., and Weleber, R.G. (1993) Genetic heterogeneity among blue cone monochromats. *American Journal of Human Genetics* 53: 987-1000.
32. Xiang, M., Zhou, L., Peng, Y.-W., Eddy, R.L., Shows, T.B., and Nathans, J. (1993) Brn-3b: a POU-domain protein expressed in a subset of retinal ganglion cells. *Neuron* 11: 689-701.
33. Sung, C.-H., Davenport, C. M., and Nathans, J. (1993) Rhodopsin mutations responsible for autosomal dominant retinitis pigmentosa: clustering of functional classes along the polypeptide chain. *Journal of Biological Chemistry* 268: 26645-26649.
34. Weitz, C., and Nathans, J. (1993) Rhodopsin activation: the effects on the metarhodopsin I - metarhodopsin II equilibrium of neutralization or introduction of charged amino acids within putative transmembrane segments. *Biochemistry* 32: 14176-14182.
35. Portera-Cailliau, C., Sung, C.-H., Nathans, J., and Adler, R. (1994) Apoptotic photoreceptor cell death in mouse models of retinitis pigmentosa. *Proceedings of the National Academy of Sciences USA* 91: 974-978.
36. Jacobson, S.G., Kemp, C.M., Cideciyan, A.V., Macke, J.P., Sung, C.-H., and Nathans, J. (1994) Phenotypes of stop codon and splice site rhodopsin mutations causing retinitis pigmentosa. *Investigative Ophthalmology and Visual Science* 35: 2521-2534.
37. Chiu, M.I., and Nathans, J. (1994) Blue cones and cone bipolar cells share transcriptional specificity as determined by expression of human blue visual pigment-derived transgenes. *Journal of Neuroscience* 14: 3426-3436.
38. Chiu, M.I., and Nathans, J. (1994) A sequence upstream of the mouse blue visual pigment gene directs blue cone-specific transgene expression in mouse retinas. *Visual Neuroscience* 11: 773-780.

39. Rosas, D.J., Roman, A.J., Weissbrod, P., Macke, J.P., and Nathans, J. (1994) Autosomal dominant retinitis pigmentosa in a large family: a clinical and molecular genetic study. *Investigative Ophthalmology and Visual Science* 35: 3134-3144.
40. Borjigin, J., and Nathans, J. (1994) Insertional mutagenesis as a probe of rhodopsin's topography, stability, and activity. *Journal of Biological Chemistry* 269: 14715-14722.
41. Chiu, M.I., Zack, D.J., Wang, Y. and Nathans, J. (1994) Murine and bovine blue pigment genes: cloning and characterization of two new members of the S family of visual pigments. *Genomics* 21: 440-443.
42. Sung, C.-H., Makino, C., Baylor, D., and Nathans, J. (1994) A rhodopsin gene mutation responsible for autosomal dominant retinitis pigmentosa results in a protein that is defective in localization to the photoreceptor outer segment. *Journal of Neuroscience* 14: 5818-5833.
43. Macke, J.P., Hennessey, J.C., and Nathans, J. (1995) Rhodopsin mutation proline347-to-alanine in a family with autosomal dominant retinitis pigmentosa indicates an important role for proline at position 347. *Human Molecular Genetics* 4: 775-776.
44. Xiang, M., Zhou, L., Macke, J.P., Yoshioka, T., Hendry, S.H.C., Eddy, R.L., Shows, T.B., and Nathans, J. (1995) The Brn-3 family of POU-domain factors: primary structure, binding specificity, and expression in subsets of retinal ganglion cells and somatosensory neurons. *Journal of Neuroscience* 15: 4762-4785.
45. Wang, Y., Macke, J.P., Abella, B.S., Andreasson, K., Worley, P., Gilbert, D.J., Copeland, N.G., Jenkins, N.A., and Nathans, J. (1996) A large family of putative transmembrane receptors homologous to the product of the *Drosophila* tissue polarity gene *frizzled*. *Journal of Biological Chemistry* 271: 4468-4476.
46. Zhou, H., Yoshioka, T., and Nathans, J. (1996) RPF-1: a complex POU-domain gene implicated in the development of retinal ganglion and amacrine cells. *Journal of Neuroscience* 16: 2261-2274.
47. Gan, L., Xiang, M., Zhou, L., Wagner, D.S., Klein, W.H., and Nathans, J. (1996) The POU domain factor Brn-3b is required for the development of a large set of retinal ganglion cells. *Proceedings of the National Academy of Sciences USA* 93: 3920-3925.
48. Xiang, M., Zhou, L., and Nathans, J. (1996) Similarities and differences among inner retinal neurons revealed by the expression of reporter transgenes under the control of Brn-3a, Brn-3b, and Brn-3c promoter sequences. *Visual Neuroscience* 13: 955-962.
49. Bhanot, P., Brink, M., Harryman Samos, C., Hsieh, J.-C., Wang, Y., Macke, J.P., Andrew, D., Nathans, J., and Nusse, R. (1996) A new member of the *frizzled* family from *Drosophila* functions as a Wingless receptor. *Nature* 382: 225-230.
50. Smallwood, P.M., Munoz-Sanjuan, I., Tong, P., Macke, J.P., Hendry, S.H.C., Gilbert, D.J., Copeland, N.G., Jenkins, N.A., and Nathans, J. (1996) Fibroblast growth factor homologous factors (FHF's): new members of the FGF family implicated in nervous system development. *Proceedings of the National Academy of Sciences USA* 93: 9850-9857.
51. Xiang, M., Gan, L., Zhou, L., Klein, W.H., and Nathans, J. (1996) Targeted deletion of the mouse POU domain gene Brn-3a causes a selective loss of neurons in the brainstem and trigeminal ganglion, uncoordinated limb movement, and impaired suckling. *Proceedings of the National Academy of Sciences USA* 93: 11950-11955.

52. Margolis, R.L., Stine, O.C., McInnes, M.G., Ranen, N.G., Rubinsztein, D.C., Leggo, J., Brando, L.V.J., Kidwai, A.S., Loev, S.J., Breschel, T.S., Callahan, C, Simpson, S.G., DePaulo, J.R., McMahon, F.J., Jain, S., Paykel, E.S., Walsh, C., DeLisi, L.E., Crow, T.J., Torrey, E.F., Ashworth, R.G., Macke, J.P., Nathans, J., and Ross, C.A. (1996) cDNA cloning of a human homologue of the *Caenorhabditis elegans* cell fate-determining gene *mab-21*: expression, chromosomal localization and analysis of a highly polymorphic (CAG)_n trinucleotide repeat. *Human Molecular Genetics* 5: 607-616.
53. Allikmets, R., Singh, N., Sun, H., Shroyer, N.F., Hutchinson, A, Chidambaram, A., Gerrard, B., Baird, I., Stauffer, D., Peiffer, A., Rattner, A., Smallwood, P., Li, Y., Anderson, K.L., Lewis, R.A., Nathans, J., Leppert, M., Dean, M. and Lupski, J.R. (1997) A photoreceptor cell-specific ATP-binding transporter gene (ABCR) is mutated in recessive Stargardt's macular dystrophy. *Nature Genetics* 15: 236-246.
54. He, X., Saint-Jeannet, J.-P., Wang, Y., Nathans, J., Dawid, I., and Varmus, R. (1997) A member of the Frizzled protein family mediating axis induction by Wnt-5A. *Science* 275: 1652-1654.
55. Rattner, A., Hsieh, J.-C., Smallwood, P.M., Debra J. Gilbert, D.J., Copeland, N.G., Jenkins, N.A., and Nathans, J. (1997) A family of secreted proteins containing homology to the cysteine-rich ligand-binding domain of frizzled receptors. *Proceedings of the National Academy of Sciences USA* 94: 2859-2863.
56. Macke, J.P. and Nathans, J. (1997) Individual variation in the size of the human red and green pigment gene array. *Investigative Ophthalmology and Visual Science* 38: 1040-1043.
57. Sun, H., Macke, J.P., and Nathans, J. (1997) Mechanisms of spectral tuning in the mouse green cone pigment. *Proceedings of the National Academy of Sciences USA* 94: 8860-8865.
58. Xiang, M., Gan, L., Li, D., Chen, Z.-Y., Zhou, L., O'Malley, B.W., Klein, W., and Nathans, J. (1997) Essential role of POU-domain factor *Brn-3c* in auditory and vestibular hair cell development. *Proceedings of the National Academy of Sciences USA* 94: 9445-9450.
59. Sun, H., and Nathans, J. (1997) Stargardt's ABCR is localized to the disc membrane of retinal rod outer segments. *Nature Genetics* 17: 15-16.
60. Sun, H., Gilbert, D.J., Copeland, N.G., Jenkins, N.A., and Nathans, J. (1997) Peropsin, a novel visual pigment-like protein located in the apical microvilli of the retinal pigment epithelium. *Proceedings of the National Academy of Sciences USA* 94: 9893-9898.
61. Sherman, P.M., Sun, H., Macke, J.P., Williams, J., Smallwood, P.M., and Nathans, J. (1997) Identification and characterization of a conserved family of protein serine/threonine phosphatases homologous to *Drosophila* retinal degeneration C (*rdgC*). *Proceedings of the National Academy of Sciences USA* 94: 11639-11644.
62. Allikmets, R., Wasserman, W.W., Hutchinson, A., Smallwood, P., Nathans, J., Rogan, P., Schneider, T.D., and Dean, M. (1998) Organization of the ABCR gene: analysis of promotor and splice site mutations. *Gene* 215: 111-122.
63. Soucy, E. Wang, Y., Nirenberg, S., Nathans, J., and Meister, M. (1998) A novel signaling pathway from rod photoreceptors to ganglion cells in mammalian retina. *Neuron* 21: 481-493.
64. Sharpe, L.T., Stockman, A., Jagle, H., Knau, H., Klausen, G., Reitner, A., and Nathans, J. (1998) Red, green, and red-green hybrid pigments in the human retina: correlations between deduced protein

- sequences and psychophysically-measured spectral sensitivities. *Journal of Neuroscience* 18: 10053-10069.
65. Munoz-Sanjuan, I., Simandl, B.K., Fallon, J.F., and Nathans, J. (1999) Expression of chicken fibroblast growth factor homologous factor-1 (FHF-1) and of differentially spliced isoforms of FHF-2 during development and involvement of FHF-2 in chicken limb development. *Development* 126: 409-421.
66. Sun, H., Molday, R. S., and Nathans, J. (1999) Retinal stimulates ATP hydrolysis by purified and reconstituted ABCR, the photoreceptor-specific ABC transporter responsible for Stargardt disease. *Journal of Biological Chemistry* 274: 8269-8281.
67. Stockman, A., Sharpe, L.T., Jagle, H., Knau, H., and Nathans, J. (1999) L, M, and L-M hybrid cone photopigments in man: deriving lambda max's from flicker photometric spectral sensitivities. *Vision Research* 39: 3513-3525.
68. Hsieh, J.-C., Rattner, A., Smallwood, P.M., and Nathans, J. (1999) Biochemical characterization of Wnt-Frizzled interactions using a soluble, biologically active vertebrate Wnt protein. *Proceedings of the National Academy of Sciences USA* 96: 3546-3551.
69. Hsieh, J.-C., Kodjabachian, L., Rebbert, M., Rattner, A., Smallwood, P.M., Harryman Samos, C., Nusse, R., Dawid, I., and Nathans, J. (1999) A new secreted protein that binds to Wnt proteins and inhibits their activities. *Nature* 398: 431-436.
70. Wang, Y., Smallwood, P. M., Cowan, M., Blesh, D., Lawler, A., and Nathans, J. (1999) Mutually exclusive expression of human red and green visual pigment-reporter transgenes occurs at high frequency in murine cone photoreceptors. *Proceedings of the National Academy of Sciences USA* 96: 5251-5256.
71. Bhanot, P., Fish, M., Jemison, J., Nusse, R., Nathans, J., and Cadigan, K.M. (1999) Frizzled and frizzled-2 function as redundant receptors for Wingless during *Drosophila* embryonic development. *Development* 126: 4175-4186.
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