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Michael F. Brown

Curriculum Vitae

DEPARTMENTS OF CHEMISTRY & BIOCHEMISTRY AND PHYSICS
UNIVERSITY OF ARIZONA
TUCSON, ARIZONA 85721

TELEPHONE: 1-520-621-2163
FAX: 1-520-621-8407
E-MAIL: MFBROWN@U.ARIZONA.EDU

ACADEMIC APPOINTMENTS

PRESENT POSITIONS:

1987– Professor of Chemistry, University of Arizona
2003– Professor of Physics, University of Arizona
2003– Professor of Applied Mathematics, University of Arizona
1993– Member, Committee on Neuroscience, University of Arizona
2008– Co-Director of Biological Physics Program, University of Arizona
2009– Co-Director of Chemical Physics Program, University of Arizona
2013– Professor, BIO5 Institute, University of Arizona

EDUCATION AND TRAINING

1975 Ph.D., University of California at Santa Cruz
1970 A.B., University of California at Santa Cruz

PROFESSIONAL EXPERIENCE

PREVIOUS POSITIONS:

1985–1987 Associate Professor of Chemistry (with Tenure), University of Virginia
1980–1985 Assistant Professor of Chemistry, University of Virginia
1979 Postdoctoral Fellow, Department of Chemistry, University of California at Berkeley
1976–1978 Postdoctoral Fellow, Biozentrum, University of Basel, Switzerland
1976–1978 Research Scientist, Max-Planck-Institute for Medical Research, Heidelberg, Germany

VISITING PROFESSORSHIPS:

2006, 2008 Visiting Professor of Physical Chemistry, University of Florence, Italy
2003–2005 Visiting Professor of Molecular Biophysics, Institute for Protein Research, Osaka Univ., Japan
2001 Visiting Professor of Physical Chemistry, University of Florence, Italy
2000 Visiting Professor of Physics, University of Würzburg, Germany
1987–1998 Visiting Professor of Physical Chemistry, University of Lund, Sweden

AWARDS AND HONORS—SELECTED

2014 Biophysical Society Avanti Award
2013 Fellow of the Galileo Circle
2013 Biophysical Society Fellow
2012 Fellow of American Association for the Advancement of Science
2011 Fellow of American Physical Society
2003–2004 Fellow of Japan Society for the Promotion of Science (Japan)
2000–2001 Senior Fulbright Fellow (Italy)
1999 Röntgen-Professorship of Physics (Germany)
1985–1990 Research Career Development Award, U.S. National Institutes of Health
1983–1985 Alfred P. Sloan Foundation Fellow
1979 U.S. National Institutes of Health Postdoctoral Fellowship, University of California at Berkeley
1976–1978 U.S. National Institutes of Health Postdoctoral Fellowship, University of Basel, Switzerland
1970–1972 University of California Predoctoral Graduate Fellowship
1970 California State Graduate Fellowship
1969 President's Scholarship, University of California
1968–1970 California State Scholarship
1968–1969 University of California Scholarship

NAMED LECTURESHIPS

The Avanti Award Lecture (Biophysical Society Meeting, San Francisco, 2014)
J. Clarence Karcher Lecturer (University of Oklahoma, 2008)
The Wilhelm Conrad Röntgen Lecture (University of Würzburg, Germany, 1999)
Richard and Patricia Wood Lecturer (University of South Florida, 1991)

NATIONAL AND INTERNATIONAL SERVICE—SELECTED

NATIONAL AND INTERNATIONAL COMMITTEES: 45th Annual Biophysical Society Meeting (Program Committee); 50th Annual Biophysical Society Meeting (Session Chair); International Advisory Committee on Retinal Proteins (2011); XXIVth International Conference on Magnetic Resonance in Biological Systems (Session Chair); American Physical Society Meeting March 2014 (Symposium Organizer and Chair)

STUDY SECTION MEMBER: U. S. Public Health Service (Beamlines and Magnets Study Section, 2005; High-End NMR Shared Instrumentation Grant Study Section, 2006; Biophysical Chemistry Study Section, 2003–2004; Biochemistry and Biophysics of Membranes Study Section– Charter Member, 2004–2010)

AD HOC STUDY SECTION MEMBER: U. S. Public Health Service (Site Visit of Harvard-MIT Center for Magnetic Resonance; Site Visit of Resource for NMR Molecular Imaging of Proteins at UCSD; Diabetes and Endocrine and Metabolic Diseases; Glue Grant; Biotechnology; Biology and Diseases of the Posterior Eye)

PROPOSAL REFEREE:

Natural Science and Engineering Council of Canada; U.S. National Science Foundation; Deutsche Forschungsgemeinschaft (Germany); Welcome Trust (U.K.); Human Frontier Science Program; Otto Klung Prize (Germany); United States Israel Binational Science Foundation (Israel); Australian Research Council; French National Research Agency; National Research Foundation of Korea

SOCIETY MEMBERSHIPS

American Chemical Society (ACS); Biophysical Society; American Physical Society (APS); American Association for the Advancement of Science (AAAS)

CURRENT RESEARCH INTERESTS

Biophysical Chemistry, Nuclear Magnetic Resonance Spectroscopy, Protein Dynamics, Membrane Biophysics

The Brown group uses molecular spectroscopy together with biophysical and biochemical methods to study lipid bilayers, proteins, and liquid crystals. Emphasis is placed on understanding the role of molecular dynamics in chemical reaction mechanisms involving protein and lipids in biomembranes. Our approach connects membrane lipid structure and dynamics with key protein-mediated signaling functions. Novel experiments are put forth, and interpreted with theory at the leading edge of biophysics and biophysical chemistry.

Solid-state and solution NMR spectral measurements of lipids and proteins are the mainstay of our experimental program. The development of new relaxation approaches and magnetic field-dependent studies of biomolecular dynamics is a major emphasis. Our biochemical investigations use rhodopsin as a prototype for G protein-coupled receptors (GPCRs). Theoretical work entails modeling of structural dynamics and relaxation; molecular dynamics computer simulations; and analysis of continuum elastic properties of membranes with differential geometry. We are particularly excited about how the actions of biomembranes are explicable in terms of structural and dynamical properties of lipids and proteins. The specific focus of our multidisciplinary research team involves the following areas:

- *Biomolecular NMR Spectroscopy:* Solid-state and solution NMR spectroscopy are used to investigate membrane proteins and lipids; by combining spin relaxation experiments and theory we explore the molecular dynamics;
- *Role of water and Lipids in Biomembrane Function:* Activation of membrane proteins is studied using the example of G-protein–coupled receptors (GPCRs); the two-way coupling of lipids and proteins is interpreted by a flexible surface model (FSM); and investigating lipid curvature elastic stress gives a connection to function;
- *Lipid Membranes as Functional Nanomaterials:* Solid-state NMR is used to explore membrane lipid structural polymorphism; our studies of collective interactions and dynamics probe the emergence of material properties of the lipid bilayers; and membrane transformations are embodied by a geometrical language of shape;
- *Reaction Mechanisms of G-Protein–Coupled Receptors:* Here the role of multi-scale dynamics in signaling by GPCRs is investigated; rhodopsin is studied to explore the membrane basis of visual excitation; and related studies of how alpha-synuclein is implicated in neurodegeneration (Parkinson's disease) are carried out;
- *Dynamics of Membrane Proteins:* Femtosecond nanocrystallography is conducted at Linac Coherent Light Source; related work involves molecular simulations and Fourier-transform infrared studies of visual pigments.

Our research at the University of Arizona is highly interdisciplinary—it encapsulates a range of interrelated scientific topics. Experiments and theory provide a confluence of biology with physics and chemistry. They give a focal point for applications of molecular spectroscopy, quantum mechanics, and statistical mechanics to investigating how lipids and proteins are implicated in the key functions of life itself!

SCIENTIFIC PUBLICATIONS

Papers: total of 145
Total Citations: 6570; H-index: 44 (Google Scholar)
Book Reviews: total of 4
Published Abstracts & Conference Presentations: total of 276
[Numbers in brackets indicate citations in Web of Science (Google Scholar) as of September 2014]
http://scholar.google.com/citations?hl=en&user=zoo_14AAAAAJ&view_op=list_works

1. Brown, M. F., and Schleich, T. (1975), Circular Dichroism and Gel Filtration Behavior of Subtilisin Enzymes in Concentrated Solutions of Guanidine Hydrochloride, *Biochemistry* **14**, 3069-3074. *[18]*
2. Brown, M. F., Miljanich G. P., Franklin, L. K., and Dratz, E. A. (1976), ^{1}H-NMR Studies of Protein-Lipid Interactions in Retinal Rod Outer Segment Disc Membranes, *FEBS Lett*. **70**, 56-60. *[22]*
3. Brown, M. F., Miljanich, G. P., and Dratz, E. A. (1977), Interpretation of 100- and 360-MHz Proton Magnetic Resonance Spectra of Retinal Rod Outer Segment Disk Membranes, *Biochemistry* **16**, 2640-2648. *[61] (64)*
4. Brown, M. F. Miljanich, G. P., and Dratz, E. A. (1977), Proton Spin-Lattice Relaxation of Retinal Rod Outer Segment Membranes and Liposomes of Extracted Phospholipids, *Proc. Natl. Acad. Sci. USA* **74**, 1978-1982. *[28]*
5. Brown, M.F., Omar, S., Raubach, R. A., and Schleich, T. (1977), Quenching of The Tyrosyl and Tryptophyl Fluorescence of Subtilisins Carslberg and Novo by Iodide, *Biochemistry* **16**, 987-992. *[22]*
6. Brown, M. F., and Schleich, T. (1977), Resolution of Independently Titrating Spectral Components in the Ultraviolet Circular Dichroism of Subtilisin Enzymes by Matrix Rank Analysis, *Biochim. Biophys. Acta* **485**, 37-51. *[8]*
7. Brown, M. F., and Seelig, J. (1977), Ion-Induced Changes in Head Group Conformation of Lecithin Bilayers, *Nature* **269**, 721-723. *[119]*
8. Brown, M. F., and Seelig, J. (1978), Influence of Cholesterol on the Polar Region of Phosphatidylcholine and Phosphatidylethanolamine Bilayers, *Biochemistry* **17**, 381-384. *[184]*
9. Omar, S., Brown, M. F., Silver, P., and Schleich, T. (1979), Histidyl and Tyrosyl Residue Ionization Studies of Subtilisin Novo, *Biochim. Biophys. Acta* **578**, 261-268. *[6]*
10. Brown, M. F., Seelig, J., and Häberlen, U. (1979), Structural Dynamics in Phospholipid Bilayers from Deuterium Spin-Lattice Relaxation Time Measurements, *J. Chem. Phys*. **70**, 5045-5053. *[192]*
11. Brown, M. F. (1979), Deuterium Relaxation and Molecular Dynamics in Lipid Bilayers, *J. Magn. Res*. **35**, 203-215. *[54]*
12. Fleischer, S., Wang, C.-T., Hymel, L., Seelig, J., Brown, M. F., Herbette, L., Scarpa, A., McLaughlin, A. C., and Blasie, J. K. (1979), Structural Studies of the Sarcoplasmic Reticulum Membrane Using the Reconstitution Approach, in *Function and Molecular Aspects of Biomembrane Transport* (Quagliariello, E., et al., Eds.) Elsevier/North-Holland, Amsterdam, pp. 465-485 (invited book chapter).
13. Deese, A. J., Dratz, E. ., and Brown, M. F. (1981), Retinal Rod Outer Segment Lipids Form Bilayers in the Presence and Absence of Rhodopsin: A ^{31}P NMR Study, *FEBS Lett*. **124**, 93-99. *[46]*
14. Brown, M. F., and Davis, J. H. (1981), Orientation and Frequency Dependence of the Deuterium Spin-Lattice Relaxation in Multilamellar Phospholipid Dispersions: Implications for Dynamic Models of Membrane Structure, *Chem. Phys. Lett*. **79**, 431-435. *[80]*
15. Brown, M. F., Deese, A. J., and Dratz, E. A. (1982), Proton, Carbon-13, and Phosphorus-31 NMR Methods for the Investigation of Rhodopsin-Lipid Interactions in Retinal Rod Outer Segment Membranes, *Methods Enzymol*. **81**, 709-728 (invited book chapter). *[30]*
16. Brown, M. F. (1982), Theory of Spin-Lattice Relaxation in Lipid Bilayers and Biological Membranes. ^{2}H and ^{14}N Quadrupolar Relaxation, *J. Chem. Phys*. **77**, 1576-1599. *[181]*

17. Brown, M. F., Ribeiro, A. A., and Williams, G. D. (1983), New View of Lipid Bilayer Dynamics From ^{2}H and ^{13}C NMR Relaxation Time Measurements, *Proc. Natl. Acad. Sci. USA* **80**, 4325-4329. *[123]*

18. Sefcik M. D., Schaefer, J., Stejskal, E. O., McKay, R. A., Ellena, J. F., Dodd, S. W., and Brown, M. F. (1983), Lipid Bilayer Dynamics and Rhodopsin-Lipid interactions: New Approach Using High-Resolution Solid-State ^{13}C NMR. *Biochem. Biophys. Res. Commun.* **114**, 1048-1055. *[40]*

19. Siminovitch, D. J., Brown, M. F., and Jeffrey, K. R. (1984), ^{14}N NMR of Lipid Bilayers: Effects of Ions and Anesthetics, *Biochemistry* **23**, 2412-2420. *[28]*

20. Siminovitch, D. J., Rance, M., Jeffrey, K. R., and Brown, M. F. (1984), The Quadrupolar Spectrum of a Spin I=1 in a Lipid Bilayer in the Presence of Paramagnetic Ions, *J. Magn. Res.* **58**, 62-75. *[50]*

21. Brown, M. F. (1984), Theory of Spin-Lattice Relaxation in Lipid Bilayers and Biological Membranes. Dipolar Relaxation, *J. Chem. Phys.* **80**, 2808-2831. *[71] (77)*

22. Brown, M.F. (1984), Unified Picture for Spin-Lattice Relaxation of Lipid Bilayers and Biomembranes, *J. Chem. Phys.* **80**, 2832-2836. *[54]*

23. Trindle, C., Brown, M., and Newton, M. G. (1984), Use of Algebraic Symbol-Manipulation Programs in Chemical Research and Education, in *Computer Education of Chemists* (P. Lykos, Ed.), Wiley, New York, pp. 93-107.

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25. Brown, M. F., and Williams, G. D. (1985), Membrane NMR: A Dynamic Research Area, *J. Biochem. Biophys. Meth.* **11**, 71-81. *[22]*

26. Williams, G. D., Beach, J. M., Dodd, S. W., and Brown, M. F. (1985), Dependence of Deuterium Spin-Lattice Relaxation Rates of Multilamellar Phospholipid Dispersions on Orientational Order, *J. Am. Chem. Soc.* **107**, 6868-6873. *[33] (36)*

27. Brown, M. F., Ellena, J. F., Trindle, C., and Williams, G. D. (1986), Frequency Dependence of Spin-Lattice Relaxation Times of Lipid Bilayers, *J. Chem. Phys.* **84**, 465-470. *[22]*

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29. Salmon, A., Dodd, S. W., Williams, G. D., Beach, J. M., and Brown, M. F. (1987), Configurational Statistics of Acyl Chains in Polyunsaturated Lipid Bilayers From ^{2}H NMR, *J. Am. Chem. Soc.* **109**, 3600-2609. *[94]*

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31. Pearlman, J. D., Zajicek, J., Merickel, M. B., Carman, C. S., Ayers, C. R., Brookeman, J. R., and Brown, M. F. (1988), High-Resolution ^{1}H NMR Spectral Signature From Human Atheroma, *Magn. Reson. Med.* **7**, 262-279. *[48] (62)*

32. Wiedmann, T. S., Pates, R. D., Beach, J. M., Salmon, A., and Brown, M. F. (1988), Lipid-Protein Interactions Mediate Photochemical Function of Rhodopsin, *Biochemistry* **27**, 6469-6474. *[126] (138)*

33. Merickel, M. B., Carman, C. S., Brookeman, J. R., Mugler, J., Brown, M. F., and Ayers, C. (1988), Identification and 3-D Quantification of Atherosclerosis Using Magnetic Resonance Imaging, *Compt. Biol. Med.* **18**, 89-102. *[45]*

34. Brown, M. F., Dodd, S. W., and Salmon, A. (1989), Deuterium NMR Spectroscopy of Saturated and Polyunsaturated Lipid Bilayers, in *Highlights of Modern Biochemistry* (Kotyk, A., et al., Eds.) VSP International, Zeist, pp. 725-734.

35. Brown, M. F., Salmon, A., Henriksson, U., and Söderman, O. (1990), Frequency Dependent ^{2}H N.M.R. Relaxation Rates of Small Unilamellar Vesicles, *Mol. Phys.* **69**, 379-383. *[18] (19)*

36. Brown, M. F., and Söderman, O. (1990), Orientational Anisotropy of Nuclear Spin Relaxation in Phospholipid Membranes, *Chem. Phys. Lett.* **167**, 158-164. *[20]*

37. Jansson, M., Thurmond, R. L., Trouard, T. P., and Brown, M. F. (1990), Magnetic Alignment and Orientational Order of Dipalmitoylphosphatidylcholine Bilayers Containing Palmitoyllyso-phosphatidylcholine, *Chem. Phys. Lipids* **54**, 157-170. *[22]*

38. Gibson, N. J., and Brown, M. F. (1990), Influence of pH on the MI-MII Equilibrium of Rhodopsin in Recombinant Membranes, *Biochem. Biophys. Res. Commun.* **169**, 1028-1034. *[19]*

39. Brown, M. F. (1990), Anisotropic Nuclear Spin Relaxation of Cholesterol in Phospholipid Bilayers, *Mol. Phys.* **71**, 903-908. *[18] (22)*

40. Thurmond, R. L., Lindblom, G., and Brown, M. F. (1990), Influences of Membrane Curvature in Lipid Hexagonal Phases Studied by Deuterium NMR Spectroscopy, *Biochem. Biophys. Res. Commun.* **173**, 1231-1238. *[17]*

41. Thurmond, R. L., Dodd, S. W., and Brown, M. F. (1991), Molecular Areas of Phospholipids as Determined By ^{2}H NMR Spectroscopy: Comparison of Phosphatidylethanolamines and Phosphatidylcholines, *Biophys. J.* **59**, 108-113. *[87] (97)*

42. Barry, J. A., Trouard, T. P., Salmon, A., and Brown, M. F. (1991), Low Temperature ^{2}H NMR Spectroscopy of Phospholipid Bilayers Containing Docosahexaenoyl (22:6w3) Chains, *Biochemistry* **30**, 8386-8394. *[34] (38)*

43. Rajamoorthi, K., and Brown, M. F. (1991), Bilayers of Arachidonic Acid Containing Phospholipids Studied By ^{2}H and ^{31}P NMR Spectroscopy, *Biochemistry* **30**, 4204-4212. *[31]*

44. Altbach, M. I., Mattingly, M., Brown, M. F., and Gmitro, A. F. (1991), Magnetic Resonance Imaging of Lipid Deposits in Human Atheroma via a Stimulated-Echo Diffusion Technique, *Magn. Reson. Med.* **20**, 319-326. *[27]*

45. Gibson, N. J., and Brown, M. F. (1991), Membrane Lipid Influences on the Energetics of the MI and MII Conformational States of Rhodopsin Probed by Flash Photolysis, *Photochem. Photobiol.* **54**, 985-992. *[29]*

46. Thurmond, R. L., Lindblom, G., and Brown, M. F. (1991), Effect of Bile Salts on Monolayer Curvature of a Phosphatidylethanolamine/Water Model Membrane System, *Biophys. J.* **60**, 728-732. *[23]*

47. Gibson, N. J., and Brown, M. F. (1991), Role of Phosphatidylserine in the MI-MII Equilibrium of Rhodopsin, *Biochem. Biophys. Res. Commun.* **176**, 915-921. *[24]*

48. Lamparski, H., Liman, U., Barry, J. A., Frankel, D. A., Ramaswami, V., Brown, M. F., and O'Brien, D. F. (1992), The Photoinduced Destabilization of Liposomes, *Biochemistry* **31**, 685-694. *[69] (76)*

49. Trouard, T. P., Alam, T. M., Zajicek, J., and Brown, M. F. (1992), Angular Anisotropy of ^{2}H NMR Spectral Densities in Phospholipid Bilayers Containing Cholesterol, *Chem. Phys. Lett.* **189**, 67-75. *[25] (28)*

50. Barry, J. A., Lamparski, H., Shyamsunder, E., Osterberg, F., Cerne, J., Brown, M. F., and O'Brien, D. F. (1992), ^{31}P NMR and X-Ray Diffraction Study of the Effect of Photopolymerization on Lipid Polymorphism, *Biochemistry* **31**, 10114-10120. *[15]*

51. Jansson, M., Thurmond, R. L., Barry, J. A., and Brown, M. F. (1992), Deuterium NMR Study of Intermolecular Interactions in Lamellar Phases Containing Palmitoyllysophosphatidycholine, *J. Phys. Chem.* **96**, 9532-9544. *[23] (24)*

52. Alexander, A. A., Pytlewski, V. T., Brown, M. F., and Gmitro, A. F. (1992), Detection of Atherosclerosis via Magnetic Resonance Imaging, *Proc. SPIE (Society of Photooptical Engineers)* **1642**, 26-33.

53. Brown, M. F., and Gibson, N. J. (1992), Biological Function of Docosahexaenoic Acid in the Retinal Rod Disk Membrane, in *Essential Fatty Acids and Eicosanoids* (Sinclair, A., and Gibson, R., Eds.), American Oil Chemist's Society Press, Champaign, Illinois, pp. 134-138 (invited review). *(6)*

54. Gibson, N. J., and Brown, M. F. (1993), Lipid Headgroup and Acyl Chain Composition Modulate the MI-MII Equilibrium of Rhodopsin in Recombinant Membranes, *Biochemistry* **32**, 2438-2454. *[130] (152)*

55. Thurmond, R. L., Lindblom, G., and Brown, M. F. (1993), Curvature, Order, and Dynamics of Lipid Hexagonal Phases Studied by Deuterium NMR Spectroscopy, *Biochemistry* **32**, 5394-5410. *[50] (58)*

56. Thurmond, R. L., Otten, D., Brown, M. F., and Beyer, K. (1994), Structure and Packing of Phosphatidylcholines in Lamellar and Hexagonal Liquid Crystalline Mixtures with a Nonionic Detergent: A Wide Line NMR Study, *J. Phys. Chem* **98**, 972-983. *[33] (39)*

57. Trouard, T. P., Alam, T. M., Job, C., and Brown, M. F. (1994), Angular Dependence of Deuterium Spin-Lattice Relaxation of Dilaurylphosphatidylcholine in the Liquid-Crystalline Phase, *J. Chem. Phys.* **101**, 5229-5261. *[35] (39)*

58. Job. C., Pearson, R., and Brown, M. F. (1994), A Personal Computer-Based NMR Spectrometer, *Rev. Sci. Inst.* **65**, 3354-3362. *[17] (23)*

59. Salamon, Z., Wang, Y., Brown, M. F., MacLeod, A., and Tollin, G. (1994), Conformational Changes in Rhodopsin Probed by Surface Plasmon Resonance Spectroscopy, *Biochemistry* **33**, 13706-13711. *[67] (78)*

60. Brown, M. F. (1994), Modulation of Rhodopsin Function by Properties of the Membrane Bilayer, *Chem. Phys. Lipids* **73**, 159-180 (invited review). *[275] (335)*

61. Schroeder, T. B., Job, C., Brown, M. F., and Glass, R. S. (1995), Indirect Detection of Selenium-77 in Nuclear Magnetic Resonance Spectra of Organoselenium Compounds, *Mag. Reson. Chem.* **33**, 191-195. *[12] (18)*

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64. Brown, M. F. (1996), Membrane Structure and Dynamics Investigated with NMR Spectroscopy, in *Membrane Structure and Dynamics* (Merz, K. M., and Roux, B., Eds.), Birkhäuser, Boston, pp. 175-252 (invited book chapter). *(42)*

65. Salamon, Z., Wang, Y., Soulages, J. L., Brown, M. F., and Tollin, G. (1996), Surface Plasmon Resonance Spectroscopy Studies of Membrane Proteins: Transducin Binding and Activation by Rhodopsin Monitored in Thin Membrane Films, *Biophys. J.* **7**1, 283-294. *[73] (79)*

66. Job, C., Zajicek, J., and Brown, M. F. (1996), Fast Field Cycling Nuclear Magnetic Resonance Spectrometer, *Rev. Sci. Instr.* **67**, 2113-2122. *[21] (30)*

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68. Nevzorov, A. A., and Brown, M. F. (1997), Dynamics of Lipid Bilayers from Comparative Analysis of ^{2}H and ^{13}C NMR Relaxation Data as a Function of Frequency and Temperature, *J. Chem. Phys.* **107**, 10288-10310. *[45] (46)*

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Book Reviews:

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Published Abstracts & Conference Presentations: total of 276
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PATENTS–TECHNOLOGY TRANSFER

1. Brown, M. F. (1990), High-Resolution Spectral Signature of Human Arterial Plaque, United States Patent 4,940,055.

STATEMENT OF CURRENT RESEARCH INTERESTS

Please see page 2

TRAINEES (PRESENT AND PAST)

Graduate Students: (Total of 28)
Postdoctoral and Research Scientists:
(Total of 8 NIH Postdocs; 1 MDA Postdoc; 1 AHA Postdoc; 2 DFG Postdocs)
Undergraduate Students (recent): (14)
High School Students: (2)

Graduate Students: (Total of 28)

PH.D. DISSERTATION DIRECTOR
Ana Vitória Botelho; Udeep Chawla; M. D. C. Suchithranga Perera; Avigdor Leftin; Alexander Nevzorov; Gilmar Salgado; Amir Salmon (NSF Predoctoral Fellow); Robin Thurmond; Theodore Trouard; Yin Wang; Gerald Williams; Xiaolin Xu; Soohyun Lee

M.S. THESIS DIRECTOR
Ana Vitória Botelho; Steven Dodd; Emily M. Dykstra; Jacob Kinnun; Karen Freedman; Pick-Wei Lau; Omar Peru; Silvia Lope-Piedrafita; Amir Salmon (NSF Predoctoral Fellow); Jay Shumway; Yin Wang; Victor Pytlewski

CO-RESEARCH DIRECTOR
Logan Ahlstrom; Tim Bartels (Technical University of Munich, Germany); Doerte Otten (University of Munich, Germany); Benjamin Schroeder; Alexander Vogel (University of Leipzig, Germany)

Postdoctoral and Research Scientists:
(Total of 8 NIH Postdocs; 1 MDA Postdoc; 1 AHA Postdoc; 2 DFG Postdocs)

Todd Alam (NIH Postdoctoral Fellow); Maria Altbach; Reza Asdjodi; Tim Bartels; Judith Barry (NIH Postdoctoral Fellow); James Beach (NIH Postdoctoral Fellow); Stuart Berr (NIH Postdoctoral Fellow); Ana Vitória Botelho; Jeffrey Ellena (NIH Postdoctoral Fellow); Nicholas Gibson; Thomas Huber; Mikael Jansson; Suhkmann Kim; K. J. Mallikarjunaiah, Karina Martínez-Mayorga; Gary Martinez (NIH Postdoctoral Fellow); Blake Mertz (NIH Postdoctoral Fellow); Stephan Moltke (Deutsche Forschungsgemeinschaft Postdoctoral Fellow) ; Trivikram Molugu; Robert Pates (MDA Postdoctoral Fellow; AHA Postdoctoral Fellow); Kannan Rajamoorthi; S. C. Shekar; Andrey Struts; Qiuke Teng; Alexander Vogel (Deutsche Forschungsgemeinschaft Postdoctoral Fellow); Timothy Wiedmann (NIH Postdoctoral Fellow); Jaroslav Zajicek

Undergraduate Students (recent):
Annie Huang (Honors); Jacob Kinnun; Emma Myers (Honors); Silvia Lope-Piedrafita (Erasmus Exchange Scholar); Israel Portillo; Edward Taylor, Kelley Sesemann (NSF REU student); Hailey Rucas; Xuemin Wang; Muwei Zheng; Jessica Wales (NSF REU student); Yi Zhang; Sabrina Lovely; Jia Ziyue; Thomas Knowles

High School Students (recent):
Megan Latifzadeh (Pima County JTED Intern); Nathan Truong (KEYS Research Intern)

S*ubsequent Accomplishments of Graduate Students and Postdoctoral Fellows (Representative):*
Theodore Trouard - currently is Associate Professor of Biomedical Engineering at University of Arizona
Alexander Nevzorov - currently is Associate Professor of Chemistry at North Carolina State University
Alexander Vogel - currently is Assistant Professor at University of Leipzig, Germany
Gilmar Salgado - currently is Assistant Professor at University of Bordeaux, France
Andrey Struts - currently is Associate Professor at St. Petersburg State University, Russia
Blake Mertz - currently is Assistant Professor of Chemistry at West Virginia University
Todd Alam - currently is Research Scientist at Sandia National Laboratory
Robin Thurmond - currently is Development Team Leader at Johnson & Johnson, San Diego
Silvia Lope-Piedrafita - currently is NMR Facility Manager at University of Barcelona, Spain
Ana Vitória Botelho - currently is Research Scientist at University of Sao Paulo, Brazil
Tim Bartels - currently is Research Associate at Harvard Medical School
Jaroslaz Zajicek- currently is NMR Facility Manager at University of Notre Dame
Avigdor Leftin - currently is National Science Foundation (NSF) Fellow and Fulbright Fellow at Weizmann Institute of Science, Israel
Benjamin Schroeder - previously was US Patent and Trademark Office Examiner; currently is Patent Attorney

FACULTY SABBATICAL AND RESEARCH VISITORS

Faculty Research Visitors:
Prof. Hideo Akutsu, Institute for Protein Research, Osaka University, Japan; Prof. Klaus Beyer, Department of Biochemistry, University of Munich, Germany; Prof. Daniel Huster, Department of Physics, University of Leipzig, Germany; Prof. Horia Petrache, Department of Physics, Indiana University-Purdue University at Indianapolis; Prof. Göran Lindblom, Department of Physical Chemistry, Umeå University, Umeå, Sweden; Prof. Maarten Heyn, Department of Physics, Free University of Berlin, Berlin, Germany; Prof. Andrey Struts, St. Petersburg State University, Russia

COLLABORATIONS WITH ACADEMIC AND INDUSTRIAL INSTITUTIONS

Arizona State University (Prof. Petra Fromme)
IBM T. J. Watson Research Center (Dr. Michael Pitman)
Osaka University, Japan, Institute for Protein Research (Profs. Hideo Akutsu, Toshimichi Fujiwara)
Humboldt University, Berlin, Germany (Drs. Franz Bartl, Eglof Ritter)
University of Leipzig, Germany (Prof. Daniel Huster, Alexander Vogel)
University of Florence, Italy (Profs. Piero Baglioni, Debra Berti)
University of California at Santa Cruz (Dr. James Lewis, Prof. David Kliger)
Indiana University-Purdue University Indianapolis (Prof. Horia Petrache)
Wabash College (Prof. Scott Feller)
University of Rochester (Prof. Alan Grossfield)
University of Freiburg, Germany (Dr. Reiner Vogel)
Eidgenössische Technische Hochschule (ETH), Paul Scherrer Institute, Switzerland (Prof. Gebhard Schertler)
University of Göteborg, Sweden (Prof. Richard Neutze)
Technical University of Munich, Germany (Prof. Bernd Reif)

TEACHING ACTIVITIES

Courses Taught in the Last Three Calendar Years
SPRING 2011:
Physical Chemistry, CHEM 480B (84 students)

FALL 2011:
Introduction to Quantum Chemistry, CHEM 580 (9 students)
NMR Spectroscopy, CHEM 584/PHYS 584/PHYS 484 (4 students)

SPRING 2012:
Biophysical Chemistry, CHEM 481 (41 students)

FALL 2012:
Introduction to Quantum Chemistry, CHEM 580 (12 students)
NMR Spectroscopy, CHEM 584/PHYS 584/PHYS 484 (6 students)

SPRING 2013:
Physical Chemistry, CHEM 480A (40 students)

FALL 2013:
Physical Chemistry, CHEM 480A (110 students)
Physical Chemistry, CHEM 480A (45 students)
NMR Spectroscopy, CHEM 584/PHYS 584/PHYS 484 (8 students)

SPRING 2015:
Physical Chemistry, CHEM 480A (37 students)

Previous Years
UNDERGRADUATE LEVEL:
Fundamentals of Chemistry, CHEM 103b (UA)
Biological Chemistry Seminar, CHEM 252 (UVa)

Biological Chemistry Seminar, CHEM 296a (UA)
Physical Chemistry, CHEM 341 (UVa)
Biological Chemistry, CHEM 442 (UVa)
Biological Chemistry Laboratory, CHEM 452 (UVa)
Physical Chemistry, CHEM 480a (UA)
Physical Chemistry, CHEM 480b (UA)
Biophysical Chemistry, CHEM 481 (UA)
NMR Spectroscopy, PHYS 484 (UA)

GRADUATE LEVEL:
Intermediate Physical Chemistry, CHEM 503 (UA)
NMR Spectroscopy, CHEM 584 and PHYS 584 (UA)
Magnetic Resonance Spectroscopy, CHEM 684 (UA)

SERVICE ACTIVITIES (LOCAL, NATIONAL, INTERNATIONAL)–RECENT

Departmental and University Service
Co-Director, Chemical Physics Program (CPP; current)
Co-Director, Biological Physics Program (BPP; current)
Chair, Physical Chemistry Division, Department of Chemistry & Biochemistry (2003-2010)
Chair, Organizing Committee, Arizona Biophest (2010, 2012, 2014)

National and International Service (Recent)
SYMPOSIUM ORGANIZER:
American Physical Society Invited Session on "Functional Dynamics of Proteins from Physics to Biology" (APS March Meeting, Denver, Colorado, 2014)

PROGRAM COMMITTEE;
45th Annual Biophysical Society Meeting (Boston, Massachusetts)

SESSION CHAIR:
50th Annual Biophysical Society Meeting (Salt Lake City, Utah)
XXIVth International Conference on Magnetic Resonance in Biological Systems (Cairns, Australia)
American Physical Society Meeting March 2014 (Denver, Colorado)

INTERNATIONAL ADVISORY COMMITTEES:
International Advisory Committee on Retinal Proteins (2011)

STUDY SECTION MEMBER:
U. S. Public Health Service (Biochemistry and Biophysics of Membranes Study Section– Permanent Member; 2004–2010)
U. S. Public Health Service (Biophysical Chemistry Study Section; 2003–2004)
U. S. Public Health Service (Beamlines and Magnets Special Emphasis Study Section; 2005)
U. S. Public Health Service (High-End NMR Shared Instrumentation Grant Special Emphasis Study Section; 2006)

AD HOC STUDY SECTION MEMBER:
U. S. Public Health Service (Biochemistry and Biophysics of Membranes Study Section)
U. S. Public Health Service (Site Visit of Resource for NMR Molecular Imaging of Proteins at UCSD)
U. S. Public Health Service (Site Visit of Harvard-MIT Center for Magnetic Resonance)
U. S. Public Health Service (NMR; Visual Sciences)
U. S. Public Health Service (Site Visit of Hormel Institute)
U. S. Public Health Service (Biology and Diseases of the Posterior Eye Study Section)
U. S. Public Health Service (Diabetes and Endocrine and Metabolic Diseases Study Section)
U. S. Public Health Service (Glue Grant Study Section)
U. S. Public Health Service (Biotechnology Study Section)

PROPOSAL REFEREE:

Agence National de la Recherche (France); U.S. National Institutes of Health; Natural Science and Engineering Council of Canada; Petroleum Research Fund; Research Corporation; U.S. National Science Foundation (Biophysics Program; Chemical Physics; Chemical Instrumentation Program); Deutsche Forschungsgemeinschaft (Germany); Katholieke Universiteit Leuven (Belgium); Welcome Trust (U.K.); U.S. Civilian Research and Development Foundation; Human Frontier Science Program; Otto Klung Prize, Free University of Berlin (Germany); United States Israel Binational Science Foundation; Australian Research Council; National Research Foundation of Korea

REFEREE FOR:
Accounts of Chemical Research; Biochemistry; Biochimica et Biophysica Acta; Biophysical Journal; Chemical Physics Letters; International Journal of Peptide and Protein Research; Journal of the American Chemical Society; Journal of Biological Chemistry; Journal of Biomolecular NMR Spectroscopy; Journal of Chemical Physics; Journal of Colloid and Interface Science; Journal of Magnetic Resonance; Journal of Physical Chemistry; Langmuir; Nature Structural & Molecular Biology; Physical Review E; Physical Review Letters; Photochemistry and Photobiology; Solid State Nuclear Magnetic Resonance; Proceedings of the National Academy of Sciences U.S.A.; PLoS Computational Biology

PUBLIC OUTREACH AND COMMUNITY SERVICE CONTRIBUTIONS–RECENT

We coordinated a laboratory visit of twelve (12) visually impaired students from Tortolita Middle School and Mountain View High School (2011). The visual process and difference between rod and cone cells in color vision was explained. Students had a chance to smell and see some of our retinal membrane samples, and they were able to watch the visual bleaching reaction. Afterwards students were instructed in the use of UV-visible spectrophotometry to characterize the visual protein rhodopsin.

The teachers who chaperoned the field trip were quite positive about the whole experience. We plan to continue these important public outreach activities in the future.

REPRESENTATIVE INVITED LECTURES–SELECTED

"Solid-State NMR Spectroscopy of Membrane Proteins and Nucleic Acids", International Symposium for Design and Synthesis of Biofunctional Molecules, Tokyo, Japan (December, 1997) - Invited Plenary Lecture

"Deuterium NMR in Liquid Crystals and Membranes", VIII International Symposium on Magnetic Resonance in Colloid and Interface Science, Namur, Belgium (May, 1998) - Invited Plenary Lecture

"NMR of Aligned Membrane Proteins and Nucleic Acids," 40th Experimental Nuclear Magnetic Resonance Conference, Orlando, Florida (March, 1999) - Invited Plenary Lecture

"Membrane Deformation on the Mesoscopic Length Scale Studied by ^{2}H NMR", German Biophysical Society Meeting, Ulm, Germany (October, 1999) - Invited Plenary Lecture

"The Investigation of Biomolecular Structure and Function Using Nuclear Magnetic Resonance Spectroscopy", Department of Physics, University of Würzburg, Germany (November, 1999) - The Röntgen Lecture

"Relaxation and Elastometry of Fluid Membranes in the Mesoscopic Regime," 43th Experimental Nuclear Magnetic Resonance Conference, Asilomar, California (April, 2002) - Invited Plenary Lecture

"Relaxometry in Elastic Deformation of Membranes on the Nanoscale", XXth International Conference on Magnetic Resonance in Biological Systems, Toronto, Canada (August, 2002) - Invited Lecture

"Site-Directed Deuterium NMR Spectroscopy of Retinal Binding Proteins in Membranes", CREST International Symposium on "Frontier in Biological NMR Spectroscopy", Osaka, Japan (January, 2004) - Invited Plenary Lecture

"Elasticity of Membrane Bilayers Probed by Solid-State ^{2}H NMR Relaxation", 36th Central Regional ACS Meeting, Indianapolis, Indiana (June, 2004) - Invited Lecture

"Rhodopsin Activation Coupled to Elastic Membrane Deformation", FASEB Summer Research Conference on "Molecular Biophysics of Cellular Membranes", Tucson, Arizona (June, 2004) - Invited Plenary Lecture

"Nuclear Spin Relaxation of Bilayer Lipids: Local or Collective Motions?", Henry Eyring Center for Theoretical Chemistry Conference on "Biological Membranes: Emerging Challenges at the Interface between Theory, Computer Simulation, and Experiment", Sun Valley, Idaho (June, 2004) - Invited Lecture

"Site-Directed ^{2}H NMR Spectroscopy of Retinal Proteins in Membranes", 15th Annual International Society of Magnetic Resonance (ISMAR) Meeting, Jacksonville, Florida (October, 2004) - Invited Lecture

"Solid-State NMR Spectroscopy of Retinal Proteins in Membranes", XXIst International Conference on Magnetic Resonance in Biological Systems (ICMRBS), Hyderabad, India (January, 2005) - Invited Lecture

"Solid State NMR Relaxation of Biomolecules", International Workshop on recent Trends in Solid State NMR in Biological Systems, Indian Institute of Science, Bangalore, India (January, 2005) - Invited Lecture

"Flexible Surface Model for Lipid-Protein Interactions", 49th Annual Biophysical Society Meeting, Long Beach, California (February, 2005) - Invited Lecture

"Chromophore Dynamics in the Binding Site of Rhodopsin from Solid State NMR", Gordon Research Conference on Photosensory Receptors and Signal Transduction, Il Ciocco, Italy (May, 2006) - Invited Plenary Lecture

"Dynamics and Relaxation of Membrane Constituents Viewed by Solid-State NMR", International Symposium on Molecular Soft Interactions in Biological Systems, Osaka, Japan (March, 2007) - Invited Lecture

"Curvature Forces in Membrane Lipid-Protein Interactions?", Park City Membrane Meeting, Park City, Utah (June, 2007) - Invited Lecture

"Retinylidene Dynamics in Rhodopsin Activation", 13th International Conference on Retinal Proteins, Barcelona, Spain (June, 2008) -Invited Plenary Lecture

"Solid-State NMR Relaxation of Rhodopsin in Membranes", 23rd International Conference on Magnetic Resonance in Biological Systems, San Diego, California (August, 2008) - Invited Lecture

"Retinal Dynamics During Rhodopsin Activation as Viewed by Solid-State NMR", International Symposium on Molecular Soft Interactions In Biological Systems, Osaka, Japan (January, 2009) - Invited Plenary Lecture

"Retinal Structure and Dynamics in Rhodopsin Activation", Department of Biophysics, Kyoto University, Japan (January, 2009) - Lecture

"NMR of Biomembranes", Indian Institute of Science, Bangalore, India (January, 2009) - Lecture

"Solid-State NMR of Biomembranes", International Symposium on Magnetic Resonance and Biomolecular Mimetics, Hyderabad, India (February, 2009) - Invited Plenary Lecture

"Solid-State NMR Relaxation of Rhodopsin in Membranes, UC Davis NMR Research Symposium (March, 2009) - Invited Keynote Presentation

"Site-Directed ^{2}H NMR Relaxation Detects Light-Induced Changes in Ligand Dynamics Upon Rhodopsin Activation", 50th Experimental Nuclear Magnetic Resonance Conference (ENC), Asilomar, California (March, 2009) - Invited Plenary Lecture

"Hydration Forces and Collective Dynamics in Biomembranes", Meeting on Biological Membranes and Membrane Proteins: Challenges for Theory and Experiment, Telluride, Colorado (July, 2009) - Invited Plenary Lecture

"Solid-State NMR of Biomembranes", Department of Physics, University of Illinois (April, 2009) - Lecture

"The Role of Lipids in GPCR Structure and Function ", Keystone Symposium on G Protein-Coupled Receptors, Breckenridge, Colorado (April, 2010) - Invited Plenary Lecture

"Beyond the Atomic Structure: Multiscale Rhodopsin Dynamics and Membrane Interactions", 14th International Conference on Retinal Proteins, Santa Cruz, California (August, 2010) - Invited Plenary Lecture

"Probing Retinal Dynamics During Rhodopsin Activation Using Deuterium Solid State Nuclear Magnetic Resonance", Pacifichem 2010, Honolulu, Hawaii (December, 2010) - Invited Lecture

"Solid-State NMR of Membrane Proteins", International Symposium on Magnetic Resonance in Pharmaceuticals and 17th Conference of National Magnetic Resonance Society (NMRS-2011), Amritsar, India (March, 2011) - Invited Plenary Lecture (declined)

"Beyond the Atomic Structure: Solid-State NMR Spectroscopy Illuminates Multi-scale Dynamics of Rhodopsin Activation", 241st ACS National Meeting (March 2011), Anaheim, California - Invited Lecture

"Ligand Dynamics in Rhodopsin Revealed by Quadrupolar Order ^{2}H NMR Relaxation ", 52nd Experimental NMR Conference (April 2011), Asilomar, California - Invited Plenary Lecture

"Solid-State ^{2}H NMR Relaxation Establishes Functional Dynamics of Retinal in Activation Mechanism of Membrane-Bound Rhodopsin", 4th Delaware Membrane Protein Symposium (May, 2011), Newark, Delaware - Invited Plenary Lecture

"Osmotic Membrane Deformation and Lipid-Protein Interactions", Meeting on Biological Membranes and Membrane Proteins: Challenges for Theory and Experiment, Snowmass, Colorado (July, 2011) - Invited Lecture

"Frustration and Dynamics In Biomembrane Function Viewed by Molecular Spectroscopy", Department of Chemistry and Department of Molecular Biology & Biochemistry, University of California at Irvine (September, 2011) - Lecture

"Flexible Surface Model for Membrane Lipid-Protein Interactions", 56th Annual Biophysical Society Meeting, San Diego, California (February, 2012) - Invited Plenary Lecture

"Curvature Forces in Membrane Lipid-Protein Interactions", American Physical Society Meeting, Boston, Massachusetts (March, 2012) - Lecture

"Frustration and Dynamics In Biomembrane Function", Department of Chemistry, Cornell University (April, 2012) - Lecture

"Membrane Proteins as Sensors of Curvature Stress", Workshop on Membrane Proteins, Arizona State University (May, 2012) - Invited Lecture

"Lipid-Mediated G-Protein–Coupled Receptor Activation", 58th Annual Biophysical Society Meeting, San Francisco, California (February, 2014) - Avanti Award Lecture

"Conformational Fluctuations in G-Protein-Coupled Receptors", American Physical Society Meeting, Denver, Colorado (March, 2014) - Invited Symposium Lecture

REFERENCES

Available upon request

STATEMENT OF TEACHING PHILOSOPHY

Discovery is the essence of all science, all learning—and probably most of human creativity. To paraphrase Richard Feynman, it doesn't matter how many times something has been discovered: when we discover it for ourselves, the creative process is just the same. By encouraging our students to see the broader unity, as brought forth by the natural sciences, one can illuminate the learning experience as an adventure that carries scholars both young and old through a lifetime of self-realization. How often have we heard from our students that they only understand it when they actually do it? Take my own education as an example: it was only when I began to conduct practical experimental studies (involving nuclear magnetic resonance spectroscopy) that it began to dawn upon me the actual meaning of the abstract quantum phenomena I learned about in lectures. I can never forget the protein spectral lines shifting before my very eyes as it underwent its function. This back and forth between doing and knowing is at the heart of some of the latest endeavors in the chemical thinking community—one would do well at every educational level to strive to bring such an approach into the classroom. That has been an ongoing effort for me—striving to illuminate actual scientific discovery, through replicating the actual process, both as it occurs individually and within a group.

But the thrill of learning requires more than brilliant rock star performances on the part of the instructor—it is not enough to listen—students must also be actively engaged! One must sing along, so to speak, maybe to be inspired, to compose. How can one bring the process of discovery into instruction in both classroom and non-classroom settings? I believe that through captivating, informative, and, maybe entertaining lectures, explications of topics can be made not only calculatedly linear and thorough, yet also engrossing, in a way that stimulates the desire for the next level of understanding. Of course what one is to learn in each day's lecture, the thrill of learning, is based in no small part on the instructor's knowledge and guidance. By providing instruction and guidance, one can take the class on a journey through even the quirky worlds of quantum phenomena in an interactive way. The aim is to keeps one's feet on the ground, with regard to how the big picture ideas such as quantum mechanics are actually seen in everyday chemical and biological applications, and how they underlie our thinking at every level.

Another question that intrigues me is: how to marry such impressionistic ideas and suggestions with the intellectual rigor and insight needed for advanced theoretical courses? How do we work intuition into the inherently heavy-duty mathematical concepts? This is an ongoing challenge for me, and I continue to be inspired and learn from my colleagues. For example, at the opposite extreme of quantum mechanics is thermodynamics—occasional derided as old fashioned (particularly by the uninformed). Yet thermodynamics is integral to the teaching of physical chemistry and chemical engineering—it is totally indispensible! Why? It must be important, so how to communicate why this is so? One obvious connection is the role of energy in human affairs, including the rise and collapse of human societies. Here too, thrilling personal and scholastic journeys can be made that illuminate the unity of knowledge thorough time, space, and culture. Indeed, the Second Law of Thermodynamics is one of the most profound statements of the inner working of the universe that has ever been made. How to communicate this profound insight in an exciting and intuitive way? My approach is to take students through the mental processes, to discover for themselves how a young counterpart from almost two hundred years ago—Sadi Carnot—was led to ask the questions that he did, to arrive at the ultimate insight—and then to promptly pass away, without ever knowing his subsequent fame. By bringing students into the processes of mental discovery at a personal level, with a connection to the thinking of someone with a potentially deep affinity, the bonds of learning and knowledge are amplified, personified, and imprinted.

In point of fact—by working to recognize student misunderstandings, bringing them to students' attention, and then promoting discovery of the solution, students at any level can achieve comprehension of even abstract or mathematical subjects. Indeed, a teacher might do well to adopt the example of Mentor—the uncle of Telemachus of Homer's Odyssey—and act as an experienced counselor or guide. There is a wonderful article by Sir Lawrence Bragg entitled "The Art of Talking about Science". Though published in 1966, the principles are timeless. I often provide it as a help to students and beginning scientists, and I read it myself, particularly before an important lecture. With this example, I strive to inspire students to see the essence of the scientific method, to learn that what is found in any textbook or contained in any lecture is a constantly evolving state of mind. Through active involvement in this seminal process, students at any level can realize their goals and aspirations—within a culture of scholarship and creativity that contributes profound benefits to humanity at large!

NARRATIVE BIOGRAPHICAL SKETCH OF MICHAEL F. BROWN

Michael Brown, Professor of Chemistry at the University of Arizona, was born in Los Angeles in 1948. He received the A.B. degree in 1970 from the University of California at Santa Cruz, as a member of the first graduating class of the newly founded campus. While an undergraduate, he conducted research in nuclear magnetic resonance (NMR) spectroscopy at the Laboratory of Chemical Biodynamics at Berkeley. He opted to stay at Santa Cruz for his doctorate, while continuing his research at Berkeley. Upon receiving the Ph.D. degree in 1975, he was awarded a postdoctoral fellowship from the U.S. National Institutes Health (NIH) to conduct research in Europe. He spent three years working with his mentor Joachim Seelig at the Biozentrum of the University of Basel in Switzerland, and with Ulrich Häberlen at the Max Planck Institute in Heidelberg, Germany.

Thereafter, he returned to the United States, where he joined the laboratory of Wayne Hubbell in the Department of Chemistry of the University of California at Berkeley. He soon began his academic career in 1980 as an Assistant Professor at the University of Virginia. He received a Sloan Fellowship and a NIH Research Career Development Award, and was promoted to Associate Professor with early tenure in 1985. In 1987 he joined the faculty of the University of Arizona as Full Professor. Michael Brown's primary appointment is in the Department of Chemistry and Biochemistry, and he holds a joint appointment in the Department of Physics. He is a member of the Committee on Neuroscience and the Applied Mathematics Program. He has been a Visiting Professor at the University of Lund, Sweden, the University of Würzburg, Germany, the University of Florence, Italy, and Osaka University, Japan.

Brown's general area of research entails biophysical chemistry—the use of principles and concepts of chemistry, physics, and mathematics to understand biological systems. He is devising and applying novel approaches involving solid-state NMR spectroscopy. Biomolecular structure and dynamics are investigated through static and time-dependent magnetic and electrical interactions. Brown and collaborators pioneered the use of deuterium NMR spectroscopy for measuring the order parameters and relaxation times of membrane proteins and lipids. His experimental measurements of the magnetic field dependence of NMR relaxation rates of liquid-crystalline systems have been crucial for validating force fields used for molecular dynamics (MD) simulations of membrane lipids and proteins. Moreover, he extended these concepts to illuminate actions of polyunsaturated lipids at the membrane level.

One of Brown's long-standing interests entails studying the visual system to unveil how membrane structure and dynamics involving G protein-coupled receptors (GPCRs) are related to their functional mechanisms. Using solid-state NMR, he established how local motions of bound cofactors initiate the activation of membrane receptors. Brown showed for the first time how light-induced changes in the local dynamics of retinal yield large-scale activating fluctuations of rhodopsin. He introduced the seminal concept of an ensemble activation model. His work continues to illuminate how the properties of biomembranes underlie key cellular functions, with potential implications for drug discovery and human medicine.

Notably, in his biophysical applications to membrane proteins, Brown was the first to put forth a new Flexible Surface Model (FSM) that supersedes the standard fluid mosaic model found in many textbooks. Two-way coupling of lipids and proteins explains membrane function by nonspecific material properties of lipid bilayers. The spontaneous monolayer curvature of the lipid leaflets competes with the solvation energy of the proteolipid interface, and underlies lipid modulation of the conformational energetics of membrane proteins. In this way, the membrane curvature stress field is linked to key biomembrane functions involving conformational changes of GPCRs and ion channels.

Michael Brown's accomplishments have been recognized through the award of Fellowships from the Alfred P. Sloan Foundation, the Japanese Foundation for the Promotion of Science, the Fulbright Program, the American Physical Society (APS), the Biophysical Society, the Galileo Circle, and the American Association for the Advancement of Science (AAAS). Most recently he received the Avanti Award in Lipids from the Biophysical Society. He is highly regarded for his creative and innovative scientific approach, for his engaging lecturing style, and his ability to communicate scientifically, both written and verbally.

MICHAEL F. BROWN– CAREER ACCOMPLISHMENTS

Michael Brown is currently a Professor of Chemistry at the University of Arizona, and holds joint positions in the Department of Physics and the Program in Applied Mathematics. He is Co-Director of the Chemical Physics Program at the University of Arizona, and is also Co-Director of the Biological Physics Program. He has an active research laboratory populated with enthusiastic undergraduate and graduate students, as well as postdoctoral scientists and visiting faculty. He proudly teaches courses in undergraduate physical chemistry (quantum mechanics, thermodynamics, kinetics, statistical mechanics) as well as graduate courses in quantum mechanics and molecular spectroscopy.

Broadly speaking Michael Brown's research entails biophysical chemistry—the use of principles and concepts of chemistry, physics, and mathematics to understand biomolecular systems in relation to their key functions. He is a leading authority on the use of solid-state NMR spectroscopy and related physical methods to study membrane lipids, liquid crystals, and membrane proteins. His original and pioneering experimental applications have led the way in terms of understanding of how biomembranes function at a very fundamental level. Michael Brown's work is a combination of theoretical insight, involving simple conceptual models, with skillful and ingenious experimental plans. His theoretical interpretations are creative and imaginative with regard to illuminating the molecular and collective dynamics of membrane lipids, and they are far reaching in significance.

Notably he was a pioneer in developing the use of deuterium (^{2}H) NMR spectroscopy for measuring the order parameters and relaxation times of biomolecules. This method has since become one of the mainstays of biophysical chemistry. He developed new solid-state NMR approaches to unveil the emergence of membrane elasticity over nano- and mesoscopic length scales. Additional NMR methods have been implemented to study the structural dynamics of membrane proteins. Michael Brown has put forth a new Flexible Surface Model (FSM) that effectively supersedes the standard fluid mosaic model found in textbooks. His innovation of a two-way coupling of lipids and proteins explains membrane protein function by nonspecific material properties of lipid bilayers. The spontaneous monolayer curvature competes with the solvation energy of the proteolipid interface, and explains lipid modulation of the conformational energetics of membrane proteins. The membrane curvature stress field is linked to key biomembrane functions involving G-protein–coupled receptors (GPCRs) and ion channels. For G-protein–coupled receptors such as rhodopsin—as well as membrane transporters and ion channels—Brown's flexible surface model illuminates how the properties of biomembranes underlie key cellular functions, with potential implications for drug discovery and human medicine.

(1) For membrane lipids, Brown pioneered the development of solid-state NMR methods (order parameter analysis, relaxation methods) in the first detailed studies of lipid structure, ordering, and dynamics. His original implementation of solid-state NMR relaxation methods led to seminal concepts of collective membrane phenomena involving elastic properties that emerge over mesoscopic length scales. Moreover, he extended these concepts to illuminate the roles of polyunsaturated lipids in biological signaling at the membrane level. His innovation (together with Prof. Joachim Seelig) of using solid-state deuterium NMR spectroscopy for investigating the structure and dynamics of liquid-crystalline molecules, including membrane lipids and membrane proteins, has had a substantial impact on the field of biophysical chemistry.

(2) Brown's experimental measurements of the magnetic field dependence of the NMR relaxation rates of liquid-crystalline systems have played a crucial role in the refinement of force fields for molecular dynamics (MD) simulations of membrane constituents. He was the first to develop a comprehensive theoretical basis of the nuclear spin relaxation of biomolecules in terms of motional mean-square amplitudes (order parameters) as well as rates of structural fluctuations. For lipid bilayers, the new model relates the energy landscape of the molecular fluctuations to the emergence of elastic properties. A membrane deformation model was proposed to establish the energy landscape in terms of viscoelastic properties that emerge on the mesoscopic length scale of the stochastic bilayer fluctuations. The combined order parameter and relaxation measurements give unique knowledge of the structural fluctuations for membrane lipids and membrane proteins. This work has had a substantial impact, and is very well cited and highly regarded in the field.

(3) Brown's work in the area of membrane lipid-protein interactions he has produced a new vision that significantly advances the field of biomembranes. He was the first to firmly establish how membrane lipids govern the energetics of membrane proteins, and he developed a new biomembrane model. His innovation of a

two-way coupling of lipids and proteins explains membrane protein function by nonspecific material properties of lipid bilayers. The new biomembrane model for lipid-protein and lipid-peptide interactions is based on differential geometry using the Helfrich free energy. According to the Flexible Surface Model, elastic deformation of the membrane bilayer is coupled to the conformational energetics of membrane proteins, including receptors and ion channels. Frustration of the intrinsic curvature of the bilayer is linked to allosteric regulation of membrane proteins that are implicated in key signaling or transport functions.

(4) Most recently, Brown has applied his methods to membrane bilayers containing the G-protein–coupled receptor (GPCR) rhodopsin. He determined the solid-state NMR structure of the retinal ligand of rhodopsin, and the changes upon light activation in the visual process. He established how local motions of bound cofactors initiate the activation of membrane receptors in a membrane lipid environment. Brown showed for the first time how light-induced changes in the local dynamics of the retinal ligand stimulate large-scale activating fluctuations of rhodopsin. He proposed and critically tested a multiscale mechanism, whereby retinal triggers collective helical fluctuations in the activated state. He introduced the concept of a dynamically activated receptor as described by an ensemble activation model. His work illuminates how the properties of biomembranes underlie key cellular functions with potential with clear implications for human medicine and drug discovery.

Michael Brown's accomplishments have been recognized through the award of Fellowships from the Alfred P. Sloan Foundation, the Japanese Foundation for the Promotion of Science, the Fulbright Program, the American Physical Society (APS), the Biophysical Society, the Galileo Circle, and the American Association for the Advancement of Science (AAAS). Among his accolades he was appointed Röntgen Professor of Physics at the University of Würzburg in Germany and delivered the Wilhelm Conrad Röntgen Lecture. He has been a Visiting Professor at the University of Lund, Sweden, the University of Florence, Italy, and Osaka University, Japan. Most recently he received the Avanti Award in Lipids from the Biophysical Society. Perhaps most importantly, Brown's talents and breadth of interest show no sign of abatement. He is passionate about his science and is currently entering the most productive phase of his career. Together with his students, he has written numerous articles in leading peer-reviewed journals. Michael Brown is highly regarded for his creative and innovative scientific approach, for his engaging lecturing style, and his ability to communicate scientifically, both written and verbally.