Curriculum Vitae

GEORGE BARANY

Addresses: Department of Chemistry
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Education: The Rockefeller University, New York, Ph.D. 1977 (with R.B. Merrifield)
Major: Biochemistry
Minors: Organic and Physical Chemistry, Mathematics
Admitted to graduate program at The Rockefeller University in 1971 directly from Stuyvesant High School, New York

Professional Experience: The Rockefeller University, Postdoctoral Fellow, 1977–1980
University of Minnesota, Assistant Professor of Chemistry, 1980–1986
Associate Professor of Chemistry, 1986–1991
Professor of Chemistry, 1991–2024
Professor of Laboratory Medicine and Pathology, 1996–2024
Member of graduate faculty, Department of Biochemistry, Molecular Biology, and Biophysics, 1997–2024
Distinguished McKnight University Professor, 1997–2024
Emeritus status as of June 2024

Honors and Awards: The Rockefeller University Graduate Fellowships, 1972–1977
USPHS Postdoctoral Fellowship (with R.B. Merrifield), 1978–1980
Searle Scholars Program, 1982–1985
USPHS Research Career Development Award, 1982–1987
"America's 100 Brightest Scientists under 40," *Science Digest* survey, December 1984
"Frontiers in Science" lecturer, Carlsberg Research Laboratories, Copenhagen,
Denmark, October 1991
Vincent du Vigneaud Award, outstanding achievements in peptide research, 1994
Distinguished McKnight University Professorship, University of Minnesota, 1997
Ralph F. Hirschmann Award in Peptide Chemistry, American Chemical Society, 2006
Murray Goodman Scientific Excellence & Mentorship Award, American Peptide Society, 2015
National Academy of Inventors, Fellow, 2020

Publications: 173 refereed journal papers, 120 refereed proceedings, 56 reviews, 40 U.S. patents, about 100 abstracts and meeting contributions

March 2024

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Curriculum Vitae (continued)

Research Interests:
peptide synthesis, particularly the solid-phase method
protecting groups for organic functionalities, with an emphasis on the concept of "orthogonality"
chemistry of thiols, disulfides, and polysulfanes
sulfurization reagents for synthetic antisense DNA and RNA
functionalization of soluble and insoluble polymers
elucidation of labile structures by mass spectrometry
pharmaceutical effects of garlic and onion constituents
rational design of protein analogues with altered specificities
mechanism of protein folding
role of sugars, phosphates, and other post-translational modifications for structure and function of peptide conjugates
preparation of DNA and peptide nucleic analogue (PNA) arrays for detection of genetic diseases [co-inventor of 'zip-code' addressing]
chemical combinatorial libraries

Extracurricular Interests:
crossword puzzle construction, tennis, opera, invention of board games

Professional Societies:
Sigma Xi, 1976
American Society for Mass Spectrometry, 1976
American Chemical Society, 1979
New York Academy of Sciences, 1980
American Association for the Advancement of Science, 1980
American Peptide Society, 1990
American Society for Biochemistry and Molecular Biology, 1993
The Protein Society, 1994

Selected Professional Activities:

American Peptide Society
Co-Creator, original American Peptide Society website (with M. Songster) at http://www.chem.umn.edu/orgs/ampepsoc/apshome.html, 1996
Program committee, Fifteenth American Peptide Symposium, 1997
Member, Publications committee, American Peptide Society, 1996–1999
Chair, Nominations committee, American Peptide Society, 1991–1993
Council, American Peptide Society, 1993–1999 (elected for 6-year term)
Co-Chair (with G.B. Fields), Sixteenth American Peptide Symposium, Minneapolis, Minnesota, June 26 – July 1, 1999; http://www1.chem.umn.edu/16aps/
Organizing committee, Merrifield Symposium, San Diego, California, June 15, 2001, "Crossroads of Chemistry and Biology"
Member, Nominations committee, American Peptide Society, 2003–2005
Head of *ad hoc* committee to create a Wikipedia page for the American Peptide Society, 2024

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Curriculum Vitae (continued)

Selected Professional Activities (continued)

Editorial Boards, Organization Boards, and Grant Review Panels

Ad hoc member, Bio-organic and natural products chemistry study section, National Institutes of Health, February 1988 and June 1991
Editorial Board, *Int. J. Peptide Protein Res.*, 1992–1996
Postdoctoral fellowship review panel, National Science Foundation, Chemistry division, February 1993
Member, Multidisciplinary special emphasis study section to review SBIR grant applications, National Institutes of Health, March 1993
Site visit team, Medical Research Council (Canada), March 1993
Editorial Board, *Letters in Peptide Science*, 1994–2004
Member, *ad hoc* review committee, National Institute on Aging, October 1994
Editorial Board, *J. Peptide Res.*, 1997–2005
Minnesota Academy of Science, Board of Directors, 1999–2002
Editorial Advisory Board, *Solid-Phase Organic Syntheses*, 1998–2012
Editorial Board, *Biopolymers (Peptide Science)*, 2004–2021
Editorial Board, *Int. J. Pept. Res. Therapeutics*, 2005–present
Editorial Board, *Chemical Biology & Drug Design*, 2006–2011

University of Minnesota (not including Department of Chemistry)

Steering committee, University of Minnesota Microchemical Facility (Departments of Microbiology, Laboratory Medicine and Pathology, and Institute of Human Genetics), 1985–1993
Steering committee, University of Minnesota Biomedical Engineering Center Mass Spectrometry Research Facility, 1992–1997
Steering committee, NIH predoctoral training grant entitled "Chemical Basis of Cellular and Molecular Biology," 1994–1996
Mentor, McNair Scholars program [to encourage and assist undergraduates who are financially disadvantaged or members of underrepresented groups], 1995, 1996, 1997, 2002, 2013
University of Minnesota, Institute of Technology, Promotion and Tenure Advisory committee, 1996–1999
Initial organizer, and later steering committee member, NIH "Chemistry–Biology Interface" predoctoral training grant (CBITG), 1999–2001
University of Minnesota, Institute of Technology Consultative Committee, 2003–2005

Consulting (selected representative)

Consultant on new methods for peptide synthesis, PE Biosystems, Framingham, Massachusetts (originally Biosearch in Novato, California), 1985–1999
Consultant on multiple syntheses and peptide drug discovery, Arris Pharmaceutical Corporation, South San Francisco, 1992–1994
Consultant on peptide synthesis reagents and resins, Peptides International, Inc., Louisville, Kentucky, 2000–present
Consultant on peptide synthesis, R & D Systems, Inc., Minneapolis, Minnesota, 2002–2003
Consultant on bio-orthogonality and silanol chemisty, Coferon, Inc., Stony Brook, NY, 2009–2010
Activities on behalf of a number of IP law firms not tabulated

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Curriculum Vitae (continued)

A total of 389 publications is divided into the following categories (listed chronologically within each category; submitted ones are also listed but not numbered):

173 refereed papers in international scientific journals, published and in press
120 refereed proceedings of scientific conferences
56 invited review articles and book chapters
40 U.S. patents issued and allowed

In addition, an estimated > 100 abstracts and meeting contributions and > 100 invited lectures and seminars are no longer tabulated.

h index 46 (Web of Science) and 71 (Google Scholar) (both checked February 2024)
orcid.org/0000-0002-6373-2706

Refereed Journal Papers

1. George Barany and R.B. Merrifield. An ATP-Binding Peptide. *Cold Spring Harbor Symposium on Quant. Biol.* **37**, 121–125 (1973).

2. George Barany and R.B. Merrifield. A New Amino Protecting Group Removable by Reduction. Chemistry of the Dithiasuccinoyl (Dts) Function. *J. Am. Chem. Soc.* **99**, 7363–7365 (1977).

3. S.B.H. Kent, A.R. Mitchell, G. Barany, and R.B. Merrifield. Test for Racemization in Model Peptide Synthesis by Direct Chromatographic Separation of Diastereomers of the Tetrapeptide Leucylalanylglycylvaline. *Anal. Chem.* **50**, 155–159 (1978).

4. George Barany, Bernard W. Fulpius, and T.P. King. Convenient New Procedures for the Synthesis of Ethoxythiocarbonyl Derivatives of Amino Acids. *J. Org. Chem.* **43**, 2930–2932 (1978).

5. George Barany and R.B. Merrifield. A Chromatographic Method for the Quantitative Analysis of the Deprotection of Dithiasuccinoyl (Dts) Amino Acids. *Anal. Biochem.* **95**, 160–170 (1979).

6. George Barany and R.B. Merrifield. Kinetics and Mechanism of the Thiolytic Removal of the Dithiasuccinoyl (Dts) Amino Protecting Group. *J. Am. Chem. Soc.* **102**, 3084–3095 (1980). With Supplementary Material: 9 pages.

7. George Barany. The Explicit Analysis of Consecutive Pseudo-First-Order Reactions: Application to Kinetics of Thiolysis of Dithiasuccinoyl (Dts) Amino Acids. *Anal. Biochem.* **109**, 114–122 (1980).

8. George Barany. Chemistry of carbamoyl disulfide protected derivatives of proline. *Int. J. Pept. Prot. Res.* **19**, 321–324 (1982).

9. George Barany. N^{α}-Dithiasuccinoyl (Dts)-L-Phenylalanine. $C_{11}H_9NO_4S_2$. *Cryst. Struct. Comm.* **11**, 913–928 (1982).

Bibliography of George Barany (continued)

Refereed Journal Papers (continued)

10. George Barany, Alayne L. Schroll, Andrew W. Mott, and David A. Halsrud. A General Strategy for Elaboration of the Dithiocarbonyl Functionality, –(C=O)SS–: Application to the Synthesis of Bis(chlorocarbonyl)disulfane and Related Derivatives of Thiocarbonic Acids. *J. Org. Chem.* **48**, 4750–4761 (1983). With Supplementary Material: 28 pages.

11. George Barany. An Unusual Rearrangement, and Further Transformations, in the Chlorination of Alkoxythiocarbonylsulfenyl Substrates. *Tetrahedron Lett.* **24**, 5683–5686 (1983).

12. Urszula Słomczyñska and George Barany. Efficient Synthesis of 1,2,4-Dithiazolidine-3,5-diones (Dithiasuccinoyl-amines) and Observations on Formation of 1,2,4-Thiadiazolidine-3,5-diones by Related Chemistry. *J. Heterocyclic Chem.* **21**, 241–246 (1984).

13. Fernando Albericio and George Barany. Application of *N,N*-dimethylformamide dineopentyl acetal for efficient anchoring of N^{α}-9-fluorenylmethyloxycarbonylamino acids as *p*-alkoxybenzyl esters in solid-phase peptide synthesis. *Int. J. Pept. Prot. Res.* **23**, 342–349 (1984).

14. George Barany and Andrew W. Mott. Chemistry of Bis(alkoxycarbonyl)polysulfanes and Related Compounds. *J. Org. Chem.* **49**, 1043–1051 (1984). With Supplementary Material: 6 pages.

15. Andrew W. Mott, Steven J. Eastep, Urszula Słomczyñska, and George Barany. Preparation of [^{18}O]-Chlorocarbonylsulfenyl Chloride. *J. Labelled Compd. Radiopharmaceut.* **21**, 329–336 (1984).

16. Andrew W. Mott and George Barany. A New Method for the Synthesis of Unsymmetrical Trisulfanes. *Synthesis*, pp. 657–660 (1984).

17. Andrew W. Mott and George Barany. Synthesis and Characterisation of Bis[(methylthio)carbonyl]polysulphanes. *J. Chem. Soc., Perkin Trans. I*, pp. 2615–2621 (1984). With Supplementary Material: 12 pages.

18. Andrew W. Mott and George Barany. The Reaction of Methoxycarbonyl Disulfanes and Trisulfanes with Hydrogen Sulfide: A New Preparation of Some Symmetrical Alkyl Pentasulfanes. *Sulfur Letters* **2**, 137–142 (1984).

19. Steven Rudd and George Barany. 3-Methyl-2(3*H*)-benzothiazolone, C_8H_7NOS. *Acta Cryst. C* **40**, 2118–2120 (1984). With Supplementary Material: 6 pages.

20. Andrew W. Mott and George Barany. Chlorination of Methylthio(thiocarbonyl) Compounds with Sulfuryl Chloride. *Sulfur Letters* **2**, 241–248 (1984).

21. Fernando Albericio and George Barany. Improved approach for anchoring N^{α}-9-fluorenylmethyloxycarbonylamino acids as *p*-alkoxybenzyl esters in solid-phase peptide synthesis. *Int. J. Pept. Prot. Res.* **26**, 92–97 (1985).

Bibliography of George Barany (continued)

Refereed Journal Papers (continued)

22. George Barany and Fernando Albericio. A Three-Dimensional Orthogonal Protection Scheme for Solid-Phase Peptide Synthesis under Mild Conditions. *J. Am. Chem. Soc.* **107**, 4936–4942 (1985). With Supplementary Material: 12 pages.

23. Alayne L. Schroll and George Barany. Novel Symmetrical and Mixed Carbamoyl and Amino Polysulfanes by Reactions of (Alkoxydichloromethyl)polysulfanyl Substrates with *N*-Methylaniline. *J. Org. Chem.* **51**, 1866–1881 (1986). With Supplementary Material: 21 pages.

24. Velta L. Sparnins, Andrew W. Mott, George Barany, and Lee W. Wattenberg. Effects of Allyl Methyl Trisulfide on Glutathione *S*-Transferase Activity and BP-Induced Neoplasia in the Mouse. *Nutrition and Cancer: An International Journal* **8**, 211–215 (1986).

25. Perry B. Hackett, Robert B. Petersen, Charles H. Hensel, Fernando Albericio, Samuel I. Gunderson, Ann C. Palmenberg, and George Barany. Synthesis *in Vitro* of a Seven Amino Acid Peptide Encoded in the Leader RNA of Rous Sarcoma Virus. *J. Mol. Biol.* **190**, 45–57 (1986).

26. Daniel G. Mullen and George Barany. A New Fluoridolysable Anchoring Linkage for Orthogonal Solid-Phase Peptide Synthesis: Preparation and Properties of the *N*-(3 or 4)-[[[(4-Hydroxymethyl)phenoxy-*t*-butylphenyl]silyl]phenyl]pentanedioic Acid, Monoamide (Pbs) Handle. *Tetrahedron Lett.* **28**, 491–494 (1987).

27. Fernando Albericio and George Barany. Mild, orthogonal solid-phase peptide synthesis: use of N^{α}-dithiasuccinoyl (Dts) amino acids and *N*-(*iso*-propyldithio)carbonylproline, together with *p*-alkoxybenzyl ester anchoring linkages. *Int. J. Pept. Prot. Res.* **30**, 177–205 (1987).

28. Fernando Albericio and George Barany. An acid-labile anchoring linkage for solid-phase synthesis of *C*-terminal peptide amides under mild conditions. *Int. J. Pept. Prot. Res.* **30**, 206–216 (1987).

29. Shmuel Zalipsky, Fernando Albericio, Urszula Słomczyñska, and George Barany. A convenient general method for synthesis of N^{α}- or N^{ω}-dithiasuccinoyl (Dts) amino acids and dipeptides: application of polyethylene glycol as a carrier for functional purification. *Int. J. Pept. Prot. Res.* **30**, 740–783 (1987).

30. Velta L. Sparnins, George Barany, and Lee W. Wattenberg. Effects of organosulfur compounds from garlic and onions on benzo[*a*]pyreneinduced neoplasia and glutathione S-transferase activity in the mouse. *Carcinogenesis* **9**, 131–134 (1988).

31. Daniel G. Mullen and George Barany. A New Fluoridolyzable Anchoring Linkage for Orthogonal Solid-Phase Peptide Synthesis: Design, Preparation, and Application of the *N*-(3 or 4)-[[4-(Hydroxymethyl)phenoxy]-*tert*-butylphenylsilyl]phenyl Pentanedioic Acid, Monoamide (Pbs) Handle. *J. Org. Chem.* **53**, 5240–5248 (1988). With Supplementary Material: 5 pages.

Bibliography of George Barany (continued)

Refereed Journal Papers (continued)

32. Alayne L. Schroll and George Barany. A New Protecting Group for the Sulfhydryl Function of Cysteine. *J. Org. Chem.* **54**, 244–247 (1989).

33. Lee W. Wattenberg, Velta L. Sparnins, and George Barany. Inhibition of *N*-Nitrosodiethylamine Carcinogenesis in Mice by Naturally Occurring Organosulfur Compounds and Monoterpenes. *Cancer Research* **49**, 2689–2692 (1989).

34. Carlos García-Echeverría, Fernando Albericio, Miquel Pons, George Barany, and Ernest Giralt. Convenient Synthesis of a Cyclic Peptide Disulfide: A Type II β-Turn Structural Model. *Tetrahedron Lett.* **30**, 2441–2444 (1989).

35. Sidney Belman, Jerome Solomon, Alvin Segal, Eric Block, and George Barany. Inhibition of Soybean Lipoxygenase and Mouse Skin Tumor Promotion by Onion and Garlic Components. *J. Biochem. Toxicology* **4**, 151–160 (1989).

36. Alayne L. Schroll, Steven J. Eastep, and George Barany. Synthesis and Characterization of (Methoxy(thiocarbonyl))sulfenyl Chloride. *J. Org. Chem.* **55**, 1475–1479 (1990). With Supplementary Material: 7 pages.

37. Fernando Albericio, Robert Van Abel, and George Barany. Solid-phase synthesis of peptides with *C*-terminal asparagine or glutamine. An effective, mild procedure based on N^{α}-fluorenylmethyloxycarbonyl (Fmoc) protection and side-chain anchoring to a tris(alkoxy)benzylamide (PAL) handle. *Int. J. Pept. Prot. Res.* **35**, 284–286 (1990).

38. Eduard Bardají, Josep L. Torres, Pere Clapés, Fernando Albericio, George Barany, and Gregorio Valencia. Solid-Phase Synthesis of Glycopeptide Amides under Mild Conditions: Morphiceptin Analogues. *Angew. Chemie Int. Ed. Engl.* **29**, 291292 (1990). Also published in German: Festphasen-Synthese von Glycopeptidamiden unter milden Bedingungen: Morphiceptin-Analoga. *Angew. Chem.* **102**, 311–313 (1990).

39. Fernando Albericio, Nancy Kneib-Cordonier, Sara Biancalana, Lajos Gera, R. Irene Masada, Derek Hudson, and George Barany. Preparation and Application of the 5-(4-(9-Fluorenylmethyloxycarbonyl)aminomethyl-3,5-dimethoxyphenoxy)valeric Acid (PAL) Handle for the Solid-Phase Synthesis of *C*-Terminal Peptide Amides under Mild Conditions. *J. Org. Chem.* **55**, 3730–3743 (1990). With Supplementary Material: 19 pages.

40. Nancy Kneib-Cordonier, Fernando Albericio, and George Barany. Orthogonal solid-phase synthesis of human gastrin-I under mild conditions. *Int. J. Pept. Prot. Res.* **35**, 527–538 (1990).

41. Robert P. Hammer, Fernando Albericio, Lajos Gera, and George Barany. Practical approach to solidphase synthesis of *C*-terminal peptide amides under mild conditions based on a photolysable anchoring linkage. *Int. J. Pept. Prot. Res.* **36**, 31–45 (1990).

Bibliography of George Barany (continued)

Refereed Journal Papers (continued)

42. Samuel Zalipsky and George Barany. Facile Synthesis of α-Hydroxy-ω-carboxymethyl-polyethylene oxide. *J. Bioactive Compatible Polymers* **5**, 227–231 (1990).

43. Mark T. Devlin, George Barany, and Ira W. Levin. Conformational Properties of Asymmetrically Substituted Mono-, Di- and Trisulfides: Solid and Liquid Phase Raman Spectra. *J. Mol. Structure* **238**, 119–137 (1990).

44. Fernando Albericio, Robert P. Hammer, Carlos García-Echeverría, M. Antònia Molins, Jane L. Chang, Mark C. Munson, Miquel Pons, Ernest Giralt, and George Barany. Cyclization of disulfide-containing peptides in solid-phase synthesis. *Int. J. Pept. Prot. Res.* **37**, 402–413 (1991).

45. Fernando Albericio and George Barany. Hypersensitive Acid-Labile (HAL) Tris(alkoxy)benzyl Ester Anchoring for Solid-Phase Synthesis of Protected Peptide Segments. *Tetrahedron Lett.* **32**, 1015–1018 (1991).

46. Eduard Bardají, Joseph L. Torres, Pere Clapés, Fernando Albericio, George Barany, Raquel E. Rodriguez, María P. Sacristán, and Gregorio Valencia. Synthesis and Biological Activity of *O*-Glycosylated Morphiceptin Analogues. *J. Chem. Soc., Perkin Trans. 1,* pp. 1755–1759 (1991).

47. Mark C. Munson, Carlos García-Echeverría, Fernando Albericio, and George Barany. *S*-2,4,6-Trimethoxybenzyl (Tmob): A Novel Cysteine Protecting Group for the N^{α}-9-Fluorenylmethyloxycarbonyl (Fmoc) Strategy of Peptide Synthesis. *J. Org. Chem.* **57**, 3013–3018 (1992).

48. Núria A. Solé and George Barany. Optimization of Solid-Phase Synthesis of [Ala^{8}]-dynorphin A. *J. Org. Chem.* **57**, 5399–5403 (1992).

49. Marc Ferrer, Clare Woodward, and George Barany. Solid-phase synthesis of bovine pancreatic trypsin inhibitor (BPTI) and two analogues. A chemical approach for evaluating the role of disulfide bridges in protein folding and stability. *Int. J. Pept. Prot. Res.* **40**, 194–207 (1992).

50. Fernando Albericio and George Barany. Acidolytic cleavage of tris(alkoxy)benzylamide (PAL) "internal reference" amino acyl (IRAA) anchoring linkages: validation of accepted procedures in solid-phase peptide synthesis (SPPS). *Int. J. Pept. Prot. Res.* **41**, 307–312 (1993).

51. Steven A. Kates, Nuria A. Solé, Charles R. Johnson, Derek Hudson, George Barany, and Fernando Albericio. A Novel, Convenient, Three-Dimensional Orthogonal Strategy for Solid-Phase Synthesis of Cyclic Peptides. *Tetrahedron Lett.* **34**, 1549–1552 (1993).

52. Elizabeth A. Ottinger, Laurie L. Shekels, David A. Bernlohr, and George Barany. Synthesis of Phosphotyrosine-Containing Peptides and Their Use as Substrates for Protein Tyrosine Phosphatases. *Biochemistry* **32**, 4354–4361 (1993).

Bibliography of George Barany (continued)

Refereed Journal Papers (continued)

53. Mark C. Munson, Michal Lebl, Jiřina Slaninová, and George Barany. Solid-Phase Synthesis and Biological Activity of the Parallel Dimer of Deamino-Oxytocin. *Pept. Res.* **6**, 155–159 (1993).

54. Sushil K. Sharma, Michael F. Songster, Tracey L. Colpitts, Peter Hegyes, George Barany, and Francis J. Castellino. Reductive Amination with Tritylamine as an Ammonia Equivalent: Efficient Preparation of the 5-[4-[[(9-Fluorenylmethyloxycarbonyl)amino]methyl]-3,5-dimethoxyphenoxy]valeric Acid (PAL) Handle for Peptide Synthesis. *J. Org. Chem.* **58**, 4993–4996 (1993). With Supplementary Material: 10 pages.

55. Mark C. Munson and George Barany. Synthesis of α-Conotoxin SI, a Bicyclic Tridecapeptide Amide with Two Disulfide Bridges: Illustration of Novel Protection Schemes and Oxidation Strategies. *J. Am. Chem. Soc.* **115**, 10203–10210 (1993).

56. Samuel Zalipsky, Jane L. Chang, Fernando Albericio, and George Barany. Preparation and applications of polyethylene glycol-polystyrene graft resin supports for solid-phase peptide synthesis. *Reactive Polymers* **22**, 243–258 (1994).

57. Marc Ferrer, George Barany, and Clare Woodward. Partially folded, molten globule and molten coil states of bovine pancreatic trypsin inhibitor. *Nature Structural Biology* **2**, 211–217 (1995).

58. Robert J. Van Abel, Yi-Quan Tang, V.S.V. Rao, Craig H. Dobbs, Dat Tran, George Barany, and Michael E. Selsted. Synthesis and characterization of indolicidin, a tryptophan-rich antimicrobial peptide from bovine neutrophils. *Int. J. Pept. Prot. Res.* **45**, 401–409 (1995).

59. Elisar Barbar, George Barany, and Clare Woodward. Dynamic Structure of a Highly Ordered β-Sheet Molten Globule: Multiple Conformations with a Stable Core. *Biochemistry* **34**, 11423–11434 (1995). With Supporting Information: 3 pages.

60. Hong Pan, Elisar Barbar, George Barany, and Clare Woodward. Extensive Nonrandom Structure in Reduced and Unfolded Bovine Pancreatic Trypsin Inhibitor. *Biochemistry* **34**, 13974–13981 (1995). With Supporting Information: 4 pages.

61. Elizabeth A. Ottinger, To Yuen Hui, Zhijun Man, George Barany, and David A. Bernlohr. *In vitro* association of the phosphatidylinositol-3-kinase regulatory subunit (p85) with the human insulin receptor. *Int. J. Pept. Prot. Res.* **46**, 346–353 (1995).

62. David Cowburn, Jie Zheng, Qinghong Xu, and George Barany. Enhanced Affinities and Specificities of Consolidated Ligands for the Src Homology (SH)3 and SH2 Domains of Abelson Protein-tyrosine Kinase. *J. Biol. Chem.* **270**, 26738–26741 (1995).

Bibliography of George Barany (continued)

Refereed Journal Papers (continued)

63. Michael F. Songster, Josef Vágner, and George Barany. Acid-labile handles for Fmoc solid-phase synthesis of peptide *N*-alkylamides. *Lett. Pept. Sci.* **2**, 265–270 (1996).

64. Elisar Barbar, George Barany, and Clare Woodward. Unfolded BPTI variants with a single disulfide bond have diminished non-native structure distant from the crosslink. *Folding & Design* **1**, 65–76 (1996) [invited research article for inaugural issue]. With Supporting Information: 8 pages.

65. Qinghong Xu, Jie Zheng, David Cowburn, and George Barany. Synthesis and characterization of branched phosphopeptides: Prototype consolidated ligands for SH(32) domains. *Lett. Pept. Sci.* **3**, 31–36 (1996).

66. Knud J. Jensen, Paul R. Hansen, D. Venugopal, and George Barany. Synthesis of 2-Acetamido-2-deoxy-β-D-glucopyranose *O*-Glycopeptides from *N*-Dithiasuccinoyl-Protected Derivatives. *J. Am. Chem. Soc.* **118***,* 3148–3155 (1996). With Supporting Information: 3 pages.

67. Qinghong Xu, Karin Musier-Forsyth, Robert P. Hammer, and George Barany. Use of 1,2,4-dithiazolidine-3,5-dione (DtsNH) and 3-ethoxy1,2,4-dithiazoline-5-one (EDITH) for synthesis of phosphorothioate-containing oligodeoxyribonucleotides. *Nucleic Acids Res.* **24**, 1602–1607 (1996).

68. Maria Kempe and George Barany. CLEAR: A Novel Family of Highly Cross-Linked Polymeric Supports for Solid-Phase Peptide Synthesis. *J. Am. Chem. Soc.* **118**, 7083–7093 (1996). With Supporting Information: 21 pages.

69. Josef Vágner, George Barany, Kit. S. Lam, Viktor Krchňák, Nikolai F. Sepetov, James A. Ostrem, Peter Štrop, and Michal Lebl. Enzyme-mediated spatial segregation on individual polymeric support beads: Application to generation and screening of encoded combinatorial libraries. *Proc. Natl. Acad. Sci. USA* **93**, 8194–8199 (1996).

70. Steven A. Kates, Núria A. Solé, Michael Beyermann, George Barany, and Fernando Albericio. Optimized Preparation of Deca(L-Alanyl)- L-Valinamide by 9-Fluorenylmethyloxycarbonyl (Fmoc) Solid-Phase Synthesis on Polyethylene Glycol-Polystyrene (PEG-PS) Graft Supports, with 1,8-Diazobicyclo[5.4.0]-undec-7-ene (DBU) Deprotection. *Pept. Res.* **9**, 106–113 (1996).

71. Lin Chen, Helena Bauerová, Jiřina Slaninová, and George Barany. Syntheses and Biological Activities of Parallel and Antiparallel Homo and Hetero Bis-Cystine Dimers of Oxytocin and Deamino-Oxytocin. *Pept. Res.* **9**, 114–121 (1996).

72. Yongxin Han, Susan L. Bontems, Peter Hegyes, Mark C. Munson, Charles A. Minor, Steven A. Kates, Fernando Albericio, and George Barany. Preparation and Applications of Xanthenylamide (XAL) Handles for Solid-Phase Synthesis of *C*-Terminal Peptide Amides under Particularly Mild Conditions. *J. Org. Chem.* **61**, 6326–6339 (1996).

Bibliography of George Barany (continued)

Refereed Journal Papers (continued)

73. Qinghong Xu, George Barany, Robert P. Hammer, and Karin Musier-Forsyth. Efficient introduction of phosphorothioates into RNA oligonucleotides by 3-ethoxy-1,2,4-dithiazoline-5-one (EDITH). *Nucleic Acids Res.* **24**, 3643–3644 (1996).

74. Lin Chen, Tracy R. Thompson, Robert P. Hammer, and George Barany. Synthetic, Mechanistic, and Structural Studies Related to 1,2,4-Dithiazolidine-3,5-dione. *J. Org. Chem.* **61**, 6639–6645 (1996).

75. Yongxin Han, Nuria A. Solé, Jan Tejbrant, and George Barany. Novel N^{ω}-Xanthenyl Protecting Groups for Asparagine and Glutamine, and Applications to N^{α}-9-Fluorenylmethyloxycarbonyl (Fmoc) Solid-Phase Peptide Synthesis. *Pept. Res.* **9**, 166–173 (1996).

76. Elizabeth A. Ottinger, Qinghong Xu, and George Barany. Intramolecular Pyrophosphate Formation during N^{α}-9-Fluorenylmethyloxycarbonyl (Fmoc) Solid-Phase Synthesis of Peptides Containing Adjacent Phosphotyrosine Residues. *Pept. Res.* **9**, 223–228 (1996).

77. Lin Chen and George Barany. *N*-Dithiasuccinoyl (Dts)-glycine: A novel oxidation reagent for the formation of intramolecular disulfide bridges under mild conditions. *Lett. Pept. Sci.* **3**, 283–292 (1996).

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Note: The majority of patents listed herein are U.S. (applied or issued), but almost all of these inventions have corresponding international patent protection.

Professor George Barany has 40 issued U.S. patents—and several more applied for—which span the fields of peptide synthesis resin supports (PEG-PS, CLEAR), peptide synthesis reagents and protecting groups (PAL, HAL, XAL, BAL, Clear-OX), technologies for the synthesis of antisense (phosphorothioate) DNA and RNA, as well as universal DNA arrays for detection of genetic diseases.

Based on information received from the Office of Technology Commercialization circa 2015, these inventions have netted nearly $1.4 million in royalties and licensing fees to the University of Minnesota, divided roughly equally between the peptide reagents and materials, and the DNA array work. In addition, Barany's work in the latter area has generated over $2 billion in revenue for over a dozen commercial entities. We do not have access to more current numbers.

GEORGE BARANY

Research Collaborators at University of Minnesota

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Andrew W. Mott, November 1982 – August 1984 [*retired 2018 from most recent*: Advisory Field Applications Scientist at Biovia, a division of Dassault Systèmes; 25 patents leading to two commercial products; Fellow of the Royal Society of Chemistry since 1996; recipient 3M Circle of Technical Excellence and Golden Step awards]

Fernando Albericio, January 1983 – December 1984 (partially supported by fellowship from Generalitat of Catalunya, Spain) [*current:* Research Professor at the University of KwaZulu-Natal (South Africa) and Emeritus Professor of Organic Chemistry at the University of Barcelona (Spain); following Executive Director of Barcelona Science Park; and Group Leader, Barcelona Biomedical Research Institute; recipient Leonid Zervas Award, European Peptide Society, 1994; named to Research Chair, Generalitat of Catalunya, 2003–2008; recipient, Vincent du Vigneaud Award, American Peptide Society, 2011; Meienhofer Award for Excellence in Peptide Society, Boulder Peptide Society, 2024]

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Daniel G. Mullen, April 2003 – March 2011 [*current*: retired from science]
Rita S. Majerle, August 2003 – September 2006 [in lab via RSEC program; retired 2023 as Associate Professor of Chemistry and past Department Head, Hamline University, St. Paul, Minnesota]
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Eric S. Goebel, August 2015 – January 2024 [*current*: Founder and Senior Chemist, Occhem LLC, Saint Paul, MN]

Graduate Students

Alayne L. Schroll, October 1980 – August 1986, Ph.D. "Novel Organosulfur Chemistry and its Applications to Peptide Synthesis. I. Preparations of Symmetrical and Mixed Carbamoyl and Amino Polysulfanes. II. A New Protecting Group for the Sulfhydryl Function of Cysteine." [*retired 2022 from most recent:* Professor of Chemistry and Leavy Family Endowed Chair of Chemistry, Chemistry Department, Saint Michael's College, Colchester, VT]
Shmuel Zalipsky, October 1981 – August 1986, Ph.D. awarded April 1987, "Development of New Functionalized Polymers and Their Utilization in Peptide Chemistry." [*current*: following numerous industrial positions, now consultant specializing in carrier-mediated drug delivery, biocompatible polymers, linker chemistry, PEGylation, lipid-based formulations, and nanoparticles]
Daniel G. Mullen, February 1982 – July 1987, Ph.D. "Design and Characterization of a Silicon-Functionalized Handle for Use in Solid-Phase Peptide Synthesis." Henkel Corporation Fellow in Chemistry, 1985-1986. [*retired 2012 from most recent*: Senior Postdoctoral Fellow, University of Minnesota, Department of Chemistry, Minneapolis, MN, following Senior Research Scientist, Integra Lifesciences Corp., San Diego, CA]
Lewis N. Bell, January 1983 – December 1985, written prelim. passed June 1983, left without writing up M.S. thesis entitled "An Acid Labile Handle for Solid-Phase Peptide Synthesis of *C*-Terminal Peptide Amides," deceased May 18, 1987
Pamela M. Fier, March 1983 – June 1984, M.S. "Syntheses of Two Putative Peptides Encoded by Rous Sarcoma Virus RNA." [*retired 2023 from most recent:* Science teacher, Marshall High School, Marshall, MN]

Research Collaborators at University of Minnesota (continued)

Graduate Students (continued)

Nancy G. Kneib-Cordonier, February 1984 – June 1989, Ph.D. "Synthesis and Characterization of a Tris(alkoxy)benzylamide Handle and its Application to the Solid-Phase Synthesis of Peptide Amides." [*retired 2023 from most recent*: Senior Staff Analytical Specialist, Kraton Corporation, Parkersburg, West Virginia; also served as Adjunct Professor of Chemistry at West Virginia University]

Robert P. Hammer, January 1986 – August 1990, Ph.D. "New Chemistry for Solid-Phase Peptide Synthesis: Anchoring, Disulfide Bond Formation, and Coupling Methods." University of Minnesota Graduate School Fellow, 1985–1987; Graduate School Dissertation Fellow, 1987–1988; Amoco Corporation Fellow, 1988–1989. [*current*: Associate Director of Medicinal Chemistry, Bicycle Therapeutics, Cambridge, MA; following Group Leader, Ra Pharmaceuticals, Cambridge, MA; following Director of Chemistry, New England Peptide, and William A. Pryor Professor of Chemistry, Louisiana State University, Baton Rouge, LA; LSU Distinguished Faculty Award, 2003; *Scientific American 50*, 2006; National Academy of Inventors Fellow, 2019; co-inventor of the peptide drug zilucoplan which is used to treat generalized myasthenia gravis]

Robert J. Van Abel, March 1988 – March 1993, was on leave August 1990 – March 1991 for Operation Desert Shield/Storm. Left to pursue interests in private industry. [*most recent*: Director of Information Technology, Marshalltown Company, Marshalltown, IA]

Mark C. Munson, March 1989 – November, 1993, Ph.D. "Synthesis of Disulfide-Containing Peptides: New Strategies and Tactics." Amoco Corporation Fellow, 1992–1993 [*current*: co-Founder and Director of Medicinal Chemistry, Sionna Therapeutics, Boston, MA; following long career with Sanofi, Waltham, MA]

Marc Ferrer, October 1989 – June 1994, Ph.D. "Chemical Synthesis and Structural Characterization of Native Sequence and Partially Folded Analogs of Bovine Pancreatic Trypsin Inhibitor (BPTI)." Fulbright Fellow, 1991–1994 [*current*: Director of 3D Tissue Bioprinting Laboratory, National Center for Advancing Translational Sciences (NCATS), Potomac, MD, following leadership positions at Merck and NIH]

Michael F. Songster, November 1989 – July 1996, Ph.D. "Design, Synthesis, and Implementation of Handles for Solid-Phase Peptide Synthesis." [*current*: Director of Information Technology, Biosearch Technologies, Inc., Novato, CA]

Elizabeth A. Ottinger, March 1990 – July 1994, Ph.D. "Development of Chemical Methods for Synthesis of Phosphorylated Peptides and Applications to Biological Problems." du Pont Fellow, 1992–1993; Stanwood Johnston Memorial Fellowship from Graduate School, 1993–1994. [*current*: Senior Project Manager, NIH, Rockville, MD]

Yongxin Han, February 1991 – October 1996, Ph.D. "Applications of Xanthenyl Chemistry to 9-Fluorenylmethyloxycarbonyl (Fmoc) Solid-Phase Peptide Synthesis." [*current*: General Manager, Centaurus BioPharma Co., Ltd, Beijing, China]

Qinghong Xu, February 1992 – November 1996, Ph.D. "I. Synthesis of Phosphorylated Peptides and Applications for Studies of Protein-Protein Interactions. II. Development of Mild Methods for the Preparation of Modified Oligonucleotides." [*current*: Partner, Lung Tin International Intellectual Property Agent Ltd, Beijing, China]

Research Collaborators at University of Minnesota (continued)

Graduate Students (continued)

Lin Chen, November 1991 – January 1997, Ph.D. "Organosulfur Chemistry and Some Applications to Peptide Synthesis." [*current*: Distinguished Scientist, Corden Pharma Colorado, Boulder, CO]

Paul R. Hansen, January 1993 – May 1994, Ph.D. granted September 1996 by Chemistry Department, Royal Veterinary and Agricultural University (Arne Holm, principal advisor in Denmark; Barany advisor for portion of work carried out at Minnesota), "New Strategies in the Synthesis of 2-Acetamido-2-deoxy-β-D-glucopyranose *O*-Glycopeptides, Neoglycoconjugates, and Photoactivatable Peptides." [*current*: Associate Professor, Department of Drug Design and Pharmacology, University of Copenhagen, Denmark]

Christopher M. Gross, January 1994 – September 2000, Ph.D. "Synthetic Studies on Bovine Pancreatic Trypsin Inhibitor (BPTI). I. Optimized Stepwise Protocols. II. Segment Condensation Strategies." NIH Training Grant Fellow, 1995–1996. [*current*: Patent Examiner, U.S. Patents and Trademarks Office, Washington, DC]

Hong Pan (Woodward laboratory), April 1994 – January 1997, Ph.D. "Nuclear Magnetic Resonance Studies of Denatured States of Bovine Pancreatic Trypsin Inhibitor." [*current*: Unknown]

Ioana Annis (nee Stoenescu), January 1995 – July 1999, Ph.D., "Design and Preparation of Novel Solid-Phase Reagents for the Formation of Sulfur-Sulfur Bridges in Peptides and Proteins under Mild Conditions." National Science Foundation Predoctoral Fellow, 1994–1997; Graduate School Dissertation Fellow, 1998–1999. [*current*: Senior R&D Specialist, The Dow Chemical Company, Buffalo Grove, IL]

Jordi Alsina, June1995 – September 1995, Ph.D. granted October 1997 by Chemistry Department, University of Barcelona (F. Albericio, advisor; Barany advisor for portion of work carried out at Minnesota), "Diseño, Síntesis y Applicaciones de Nuevos Espaciadores Bifuncionales en Síntesis de Péptidos en Fase Sólida." [*current*: listed with postdoctoral fellows]

Balazs Hargittai, January 1996 – August 1999, Ph.D. awarded January, 2000, "I. Chemical Syntheses and Biological Activities of Disulfide-Paired Isomers and Lactam Analogues of Alpha-Conotoxin SI. II. A New Side-Chain Anchoring Strategy for Solid-Phase Synthesis of Peptide Acids with *C*-Terminal Cysteine." [*current*: Professor of Chemistry and Chair, Saint Francis University, Loretto, PA]

Natàlia Carulla-Casanovas, November 1996 – September 2001. Ph.D., "Design, Synthesis, and Characterization of Beta-Sheet Peptides and Proteins." Louise T. Dosdall Fellowship from Graduate School, 1999–2000; Graduate School Dissertation Fellow, 2000–2001. [*current*: Project Manager Grup CIEF, Barcelona, Spain; following academic research positions at the Institut de Recerca Biomédica de Barcelona and the Institut Européen de Chimie et Biolgie (IECB); recipient 2004 Reincorporation Fellowship from the Generalitat de Catalunya]

Joseph C. Kappel, November 1996 – October 2003, Ph.D. "Synthetic Strategies for Solid-Phase Synthesis: I. Design, Synthesis, and Applications of Handles. II. Combinatorial Synthesis of Small Molecules." NIH Biotechnology Training Grant Fellow, 1998 – 2000 [*current*: Associate Professor, Jackson State Community College, Jackson, TN]

Research Collaborators at University of Minnesota (continued)

Graduate Students (continued)

Simon K. Shannon, January 1998 – November 2003, Ph.D. "Development of New Tools for Solid-Phase Organic Library Synthesis: Backbone Amide Linker (BAL) Anchoring Approaches and Monitoring Methods." NIH Biotechnology Training Grant Fellow, 2003 [*current*: Director, Business Development at 3M, St. Paul, MN; Founding President of University of Minnesota chapter of National Organization of Black Chemists and Chemical Engineers (NOBCChE); recipient TRIO Achievement Award, 2014; University of Minnesota Morris Distinguished Alumni Award, 2023]

Judit Tulla Puche, August 2000 – February 2004, Ph.D. "I. Palladium-Mediated Strategies for the Synthesis of Small Molecules. II. Synthetic Studies Towards Partially Folded Peptides." [*last known*: Senior Scientist, Barcelona Science Park, Barcelona, Spain]

Larry R. Masterson, May 2004 – December 2008, Ph.D. (G-l. Veglia, advisor; Barany co-advisor), "Towards the Full Molecular Details of Protein Kinase A Mediated Catalysis by NMR Spectroscopy." NIH Chemistry Biology Interface Training Grant, July 2005 – June 2006 [*last known*: Assistant Professor of Chemistry, Hamline University, St. Paul, Minnesota]

Andrew J. Borgert, September 2003 – January 2009, Ph.D. (D. Live, advisor; Barany co-advisor), "Structural Consequences of Mucin Glycosylation." [*current*: Biostatistician, Department of Medical Research, Gundersen Lutheran Medical Foundation, La Crosse, WI]

Sadia Noor, July 2016 – January 2017, visiting scholar under the sponsorship of the Higher Education Commission of Pakistan; work done in my lab formed a chapter in her 2019 Ph.D. thesis.

In addition, well over a hundred University of Minnesota undergraduate students [a number of whom held University Research Opportunity Program (UROP), Lando, McNair, or other fellowships] have conducted research in the Barany laboratory, and quite a few of whom were coauthors on refereed journal publications. I have also mentored a number of high school students, including two who were supported by the American Chemical Society's Project SEED [Summer Research Internship Program for Economically Disadvantaged High School Students].