

July 15, 2018

JULIO M. OTTINO
CURRICULUM VITAE

Personal

US citizen¹, born in La Plata, Argentina.
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Education

Ph.D. in Chemical Engineering, University of Minnesota, 1979.
Chemical Engineering Diploma, National University of La Plata, Argentina, 1974.
Executive Program, Kellogg School of Management, 1995.

Current Position

Dean, R.R. McCormick School of Engineering and Applied Science, 2005-
R.R. McCormick Institute Professor, Northwestern University, 2000-
Walter P. Murphy Professor, Chemical Engineering, Northwestern University, 1991-
Professor (by courtesy), Mechanical Engineering, Northwestern University, 2000-

Teaching and Research Positions

Co-Director, the Northwestern Institute on Complex Systems, 2004-2005.
Chair, Department of Chemical Engineering, Northwestern University, 1992-2000.
Professor of Chemical Engineering, Northwestern University, 1991-
George T. Piercy Distinguished Professor, Department of Chemical Engineering and Materials
Sciences, University of Minnesota, 1998.
Senior Research Fellow, Center for Turbulence Research, Stanford University, 1990.
Professor, Department of Chemical Engineering, University of Massachusetts, Amherst, 1986-1991.
Chevron Visiting Associate Professor of Chemical Engineering, California Institute of Technology,
1986.
Associate Professor, Department of Chemical Engineering, University of Massachusetts, Amherst,
1983-1986.
Adjunct Professor, Department of Polymer Science and Engineering, University of Massachusetts,
Amherst, 1979-1991.
Assistant Professor, Department of Chemical Engineering, University of Massachusetts, Amherst,
1979-1983.
Instructor, Department of Chemical Engineering, University of Minnesota, Minneapolis, 1978-1979.

Honors and Significant Lectureships

2018 William M.W. Mong Distinguished Lecture, University of Hong Kong
2018 John C. Chen Distinguished Lecture, Department of Chemical and Biomolecular
Engineering, Lehigh University

¹Naturalized March 21, 1991, Northampton, Massachusetts.

2017 Bernard M. Gordon Prize for Innovation in Engineering and Technology Education, National Academy of Engineering
2016 Schlinger Symposium opening plenary address, Chemical Heritage Foundation
2015 SABIC Lectureship Award, Polymer Engineering, University of Akron
2015 Institute of Molecular Engineering Distinguished Lectures, University of Chicago
2014 4th KAIST CBE Global Distinguished Lectureship, Korea
2014 2nd Thomas H. Chilton Lecture, du Pont Central Research and Development
2013 Creativity in Science and Society, Symposium Celebrating Niels Bohr, Royal Danish Academy of Sciences and Letters, Copenhagen
2013 Alumni Endowed Lectures in Chemical Engineering, UMass-Amherst
2013 Fellow, American Institute of Chemical Engineers
2013 Distinguished Lecture, Chemical Engineering, Syracuse University
2012 Distinguished Research Lecture in Chemical Engineering, Carnegie Mellon University
2012 Eminent Lecturer, National Technical University Singapore
2012 TechniGraphicS Foundation Lecture, IIT Bombay, India
2012 Keynote ASME Design Automation Conference, Chicago
2011 Keynote ASME Dynamics Systems and Control Conference, Washington DC
2010 62nd Institute Lecture, American Institute of Chemical Engineers
2008 Fluid Dynamics Prize, American Physical Society
2008 Otto Laporte Lecture, American Physical Society
2008 AIChE 100th Anniversary “One Hundred Engineers of the Modern Era”, American Institute of Chemical Engineers.
2008 μ TAS (12th International Conference on Miniaturized Systems for Chemistry and Life Sciences, San Diego).
2007 Pirkey Lecture, University of Texas, Austin
2006 Dean’s Distinguished Lecture, College of Engineering and Mathematical Sciences, University of Vermont
2006 Reilly Lectures University of Notre Dame
2003 Member, American Academy of Arts and Sciences
2002 Ernest W. Thiele Award (AIChE, Chicago section)
2002 Robb Distinguished Lecture in Chemical Engineering Science, Penn State University
2001 William H. Walker Award, American Institute of Chemical Engineers
2001 John S. Guggenheim Fellowship
2001 Paul J. Flory Lecturer, Stanford University
1999 Danckwerts Memorial Lecture, London, England
1997 Member, National Academy of Engineering
1996 Fellow, American Association for the Advancement of Science
1996 Sigma Xi Distinguished Lecturer (1997-1999)
1996 SON Lecture (Foundation for Chemical Research, The Netherlands)
1995 Faculty Honor Roll, Associate Student Government, Northwestern University
1994 Alpha Chi Sigma Award, American Institute of Chemical Engineers
1994 William N. Lacey Lectureship in Chemical Engineering, California Institute of Technology
1994 College of Engineering Centennial Speaker, University of Maryland
1993 Fellow, American Physical Society, Division of Fluid Mechanics
1991 Fifth Stanley Corrsin Lectureship in Fluid Mechanics, The Johns Hopkins University
1989 Finalist Scientific Prize, Art for Science, LV-MH, Paris, France
1989 Merck Sharp & Dohme Lecturer, University of Puerto Rico
1988 University Fellow, University of Massachusetts
1987 Allan P. Colburn Memorial Lectureship, Chemical Engineering, University of Delaware
1984 Presidential Young Investigator Award (NSF)

1982 Outstanding Junior Faculty Scholar Award (University of Massachusetts)

Selected professional activities

- Vice Chair, Draper Prize Committee, National Academy of Engineering; Member 2014- vice chair 2017, chair 2019.
- Co-Chair (with John Guckenheimer, Mathematics, Cornell University) “*Foundations for Complex Systems: Research in the Physical Sciences and Engineering*” (report from an NSF Workshop, September 2008).
- Member of several NRC committees, Benchmarking Committee, US Chemical Engineering (2007), Committee on the Challenges for the Chemical Sciences (2002-3) Draper Prize Committee (2014-).
- AIChE Chemical Engineering Operating Council, 2002-Benchmarking Committee, US
- Member International Review of Engineering in the UK –EPSRC/Royal Academy of Engineering (2004).
- Member NAE Committee on Membership (2003-2006)
- Founding Editor, *AIChE Journal*, Perspectives (1999-2006); Associate Editor (1994-2006)

Selected boards and advising activities

- Takata Quality Assurance Panel, 2015; www.takatapanel.com
- Scientific Board, AkzoNobel, 2010-2013
- Noribachi LLC, Albuquerque, New Mexico, 2008-2010
- Member, International Advisory Board, UC Santa Barbara (2005-2010)
- Unilever, Senior Advisor (1997-2008)
- Dow Chemical (Engineering Sciences Technical Advisory Board, 2000-2004).
- Member program reviews at Cornell, Houston, U.C. Santa Barbara, etc.

CURRENT AREAS OF RESEARCH

Granular Dynamics, Mixing – Fluid Dynamics, Segregation and Coarsening, Complex Systems.

Publications in Refereed Journals: Over 230 publications in refereed journals; ISI *h*-index: 57, Google Scholar *h*-index: 69; book “*The Kinematics of Mixing*” has been cited over 2,900 times. Publications have appeared in the following journals:

1. *Advances in Chemical Engineering*
2. *Advances in Complex Systems*
3. *American Institute of Chemical Engineers Journal*
4. *American Journal of Physics*
5. *Annals of Biomedical Engineering*
6. *Annual Reviews of Fluid Mechanics*
7. *Archives for Rational Mechanics and Analysis*
8. *Biotechnology Progress*
9. *Cardiovascular Engineering and Technology*
10. *Chaos*
11. *Chaos, Solitons and Fractals*
12. *Chemical Engineering Communications*
13. *Chemical Engineering Education*
14. *Chemical Engineering Science*
15. *European Journal of Physics*
16. *European Phys. Letters*
17. *Exp. Thermal Fluid Sci.*
18. *Geophysical Research Letters*
19. *Granular Matter*

20. *Industrial Engineering Chemistry Fundamentals*
21. *Industrial Engineering Chemistry Research*
22. *International Journal of Multiphase Flow*
23. *Int. J. Bifurcations and Chaos*
24. *Journal of Chemical Physics*
25. *Journal of Colloid and Interface Science*
26. *Journal of Fluid Mechanics*
27. *Journal of Non-Newtonian Fluid Mechanics*
28. *Lectures in Applied Mathematics*
29. *Macromolecules*
30. *Nature*
31. *Nature Communications*
32. *Nature Physics*
33. *New Journal of Physics*
34. *Philosophical Transactions of the Royal Society of London*
35. *Physica D*
36. *Physical Review A*
37. *Physical Review E*
38. *Physical Review Letters*
39. *Physics of Fluids and Physics of Fluids A*
40. *Polymer*
41. *Polymer Engineering Science*
42. *Powder Technology*
43. *Proceedings of the National Academy of Sciences of the US*
44. *Proceedings of the Royal Society of London*
45. *SIAM Journal on Applied Dynamical Systems*
46. *Soft Matter*
47. *Science*
48. *Tribology Letters*

Publications in Magazines

49. *CHEMTECH*
50. *INGENIA*
51. *Scientific American*
52. *The Chronicle of Higher Education*

PUBLICATIONS

Books

J.M. Ottino, *The Kinematics of Mixing: Stretching, Chaos, and Transport*, Cambridge University Press, Cambridge, England 1989 (xiv, 364 pp., illus., + plates), reprinted 1990, 1997; 2004.

R. Sturman, J.M. Ottino, and S. Wiggins, *Mathematical Foundations of Mixing: The Linked Twist Map as a Paradigm in Applications – Micro to Macro, Fluids to Solids*, Cambridge University Press, Cambridge, England, 2006

Publications in Refereed Journals, Technical Papers

J.M. Ottino, W.E. Ranz, and C.W. Macosko, A lamellar model for analysis of liquid-liquid mixing, *Chem. Eng. Sci.*, **34**, 877-890 (1979).

J.M. Ottino and C.W. Macosko, An efficiency parameter for batch mixing of viscous liquids, *Chem. Eng. Sci.*, **35**, 1454-1457 (1980).

J.M. Ottino, Lamellar mixing models for structured chemical reactions and their relationship to statistical models; Macro- and micro-mixing and the problem of averages, *Chem. Eng. Sci.*, **35**, 1377-1391 (1980).

L.J. Lee, J.M. Ottino, W.E. Ranz, and C.W. Macosko, Impingement mixing in reaction injection molding, *Polym. Eng. Sci.*, **20**, 868-874 (1980).

J.M. Ottino, Efficiency of mixing from data on fast reactions in multi-jet reactors and stirred tanks, *AIChE Journal*, **27**, 184-192 (1981).

J.M. Ottino, C.W. Macosko, and W.E. Ranz, Framework for the description of mechanical mixing of fluids, *AIChE Journal*, **27**, 565-577 (1981).

J.M. Ottino and H.T. Davis, Pressure tensor in lamellarly structured fluids, *J. Chem. Phys.*, **74**, 6388-6393 (1981).

J.M. Ottino, Description of mixing with diffusion and reaction in terms of the concept of material interfaces, *J. Fluid Mech.*, **114**, 83-103 (1982).

K.K. Mohanty, J.M. Ottino, and H.T. Davis, Reaction and transport in disordered composite media: Introduction of percolation concepts, *Chem. Eng. Sci.*, **37**, 905-924 (1982).

R. Chella and J.M. Ottino, Simplified model for mechanical mixing, diffusion, and reaction in a single screw extruder, *ACS Symp. Ser.*, **196**, 567-578 (1982).

J.M. Ottino, A mechanical mixing parameter for continuous mixing systems, *AIChE Journal*, **29**, 159-161 (1983).

R. Chella and J.M. Ottino, Modeling of rapidly-mixed fast-crosslinking exothermic polymerizations I: Adiabatic temperature rise, *AIChE Journal*, **29**, 373-382 (1983).

J.E. Sax and J.M. Ottino, Transport of small molecules in polymer blends: Application of effective medium theory, *Polym. Eng. Sci.*, **23**, 165-176 (1983).

J.M. Ottino and R. Chella, Mixing of polymeric liquids: A brief review and recent theoretical developments, *Polym. Eng. Sci.*, **23**, 357-379 (1983).

J.M. Ottino and N. Shah, Analysis of transient sorption and permeation of small molecules in multiphase polymer systems, *Polym. Eng. Sci.*, **24**, 153-162 (1984).

R. Chella and J.M. Ottino, The fluid mechanics of mixing in a single screw extruder, *Ind. Eng. Chem. Fundam.*, **24**, 170-180 (1985).

- R. Chella and J.M. Ottino, Conversion and selectivity modifications due to mixing in unpremixed Reactors, *Chem. Eng. Sci.*, **39**, 551-567 (1984).
- J.E. Sax and J.M. Ottino, Influence of morphology on the transport properties of polystyrene/polybutadiene blends: Experimental results, *Polymer*, **26**, 1073-1080 (1985).
- N. Shah, J.E. Sax, and J.M. Ottino, Influence of morphology on the transport properties of polystyrene/polybutadiene blends: Modeling results, *Polymer*, **26**, 1229-1246 (1985).
- R. Chella and J.M. Ottino, Stretching in some classes of fluids motions and asymptotic mixing efficiencies as a measure of flow classification, *Arch. Rat. Mech. Anal.*, **90**, 15-45 (1985).
- D.J. Lin, J.M. Ottino, and E.L. Thomas, A kinetic study of the activated anionic polymerization of ϵ -Caprolactam, *Polym. Eng. Sci.*, **25**, 1155-1163 (1985).
- N. Shah and J.M. Ottino, Effective transport properties of random multi-phase composites: Application of renormalization Theory, *Chem. Eng. Sci.*, **41**, 283-296 (1986).
- D.V. Khakhar and J.M. Ottino, A note on the linear vector model of Olbricht, Rallison, and Leal as applied to the breakup of slender axisymmetric drops, *J. Non-Newtonian Fluid Mech.*, **21**, 127-131 (1986).
- D.V. Khakhar and J.M. Ottino, Deformation and breakup of slender drops in linear flows, *J. Fluid Mech.*, **166**, 265-285 (1986).
- W.L. Chien, H. Rising, and J.M. Ottino, Laminar and chaotic mixing in several cavity flows, *J. Fluid Mech.*, **170**, 355-377 (1986).
- D.V. Khakhar, H. Rising, and J.M. Ottino, An analysis of chaotic mixing in two model systems, *J. Fluid Mech.*, **172**, 419-451 (1986).
- D.V. Khakhar and J.M. Ottino, Fluid mixing (stretching) by periodic sequences for weak flows, *Phys. Fluids*, **29**, 3503-3505 (1986).
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- N. Shah and J.M. Ottino, Transport and reaction in evolving, disordered composites: I. Gasification of porous solids, *Chem. Eng. Sci.*, **42**, 63-72 (1987).
- N. Shah and J.M. Ottino, Transport and reaction in evolving, disordered composites: II. Coke deposition in a catalytic pellet, *Chem. Eng. Sci.*, **42**, 73-82 (1987).
- S.D. Fields and J.M. Ottino, Mixing effects during polymerizations by the adiabatic temperature rise technique, *AIChE Journal*, **33**, 157-160 (1987).
- D.V. Khakhar and J.M. Ottino, Breakup of liquid threads in linear flows, *Int. J. Multiphase Flow*, **13**, 71-86 (1987).
- S.D. Fields and J.M. Ottino, Effect of striation thickness distribution on the course of an unpremixed polymerization, *Chem. Eng. Sci.*, **42**, 459-465 (1987).

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- D.J. Kinning, E.L. Thomas, and J.M. Ottino, Effect of morphology on the transport of small molecule gases in block copolymers, *Macromolecules*, **20**, 1129-1133 (1987).
- S.D. Fields and J.M. Ottino, Effects of segregation on the course of unpremixed polymerizations, *AIChE Journal*, **33**, 959-975 (1987).
- M. Serrano, W.J. MacKnight, E.L. Thomas and J.M. Ottino, Transport-morphology in polybutadiene polyurethanes. 1: Experimental results, *Polymer*, **28**, 1667-1673 (1987).
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- D.V. Khakhar, J.G. Franjione, and J.M. Ottino, A case study of chaotic mixing in deterministic flows: The partitioned pipe mixer, *Chem. Eng. Sci.*, **42**, 2909-2926 (1987).
- J.G. Franjione and J.M. Ottino, Feasibility of numerical tracking of material lines and surfaces in chaotic flows, *Phys. Fluids*, **30**, 3641-3643 (1987).
- E.M. Sevick, P.A. Monson, and J.M. Ottino, Monte Carlo calculations of cluster statistics in continuum models of composite morphology, *J. Chem. Phys.*, **88**, 1198-1206 (1988).
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[reprinted in "*Chaos and Nonlinear Dynamics*" edited by R.C. Hilborn and N.B. Tuffillaro, American Association of Physics Teachers, College Park, Maryland, 1999.]
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- E.M. Sevick, P.A. Monson, and J.M. Ottino, Clustering and percolation in assemblies of anisotropic particles: Perturbation theory and Monte Carlo simulation, *Phys. Rev. A.*, **38**, 5376-5383 (1988).
- J.M. Ottino, The mixing of fluids, *Scientific American*, **260**, 56-67 (1989) (*cover article*).
[translations appeared in *Pour la Science*, Le mélange des fluides, mensuel **137**, 32-42, Mars 1989, and *Investigacion y Ciencia*, Mezcla de Fluidos, Número **150**, 44-55, Marzo (1989); *Le Scienze*, Il Mescolamento dei Fluidi, n° **247**, 152-161 (1989); *Mischen zäher Flüssigkeiten*, Spektrum der Wissenschaft, März (1989), S66 - 77].
- E.M. Sevick, P.A. Monson, and J.M. Ottino, Morphology and transport using the Ising lattice as a morphology description, *Chem. Eng. Sci.*, **44**, 21-32 (1989).
- H.A. Kusch, J.M. Ottino, and D.M. Shannon, Analysis of impingement mixing-reaction data: Use of a lamellar model to generate fluid mixing information, *Ind. Eng. Chem. Res.*, **28**, 302-315 (1989).

- F. J. Muzzio and J.M. Ottino, Evolution of a lamellar system with diffusion and reaction: A scaling approach, *Phys. Rev. Lett.*, **63**, 47-50 (1989).
- C.-W. Leong and J.M. Ottino, Experiments on mixing due to chaotic advection in a cavity, *J. Fluid Mech.*, **209**, 463-499 (1989).
- J.G. Franjione, C.W. Leong, and J.M. Ottino, Symmetries within chaos: a route to effective mixing, *Phys. Fluids A*, **1**, 1772-1783 (1989).
- F. J. Muzzio and J.M. Ottino, Dynamics of a lamellar system with diffusion and reaction: Scaling analysis and global kinetics, *Phys. Rev. A*, **40**, 7182-7192 (1989).
- J.M. Ottino, Mixing, Chaotic advection, and turbulence, *Ann. Revs Fluid Mech.*, **22**, 207-54 (1990).
- C.-W. Leong and J.M. Ottino, Increase in regularity by polymer addition during chaotic mixing in two-dimensional flows, *Phys. Rev. Lett.*, **64**, 874-877 (1990).
- P.D. Swanson and J.M. Ottino, A comparative computational and experimental study of chaotic mixing of viscous fluids, *J. Fluid Mech.*, **213**, 227-249 (1990).
- T.J. Danielson and J.M. Ottino, Structural stability in two-dimensional model flows: Lagrangian and Eulerian turbulence, *Phys. Fluids A*, **2**, 2024-2035 (1990).
- F.J. Muzzio and J.M. Ottino, Diffusion and reaction in a lamellar system: Self-similarity with finite rates of reaction, *Phys. Rev. A*, **42**, 5873-5884 (1990).
- J.M. Ottino, Unity and Diversity in Mixing: Stretching, diffusion, breakup, and aggregation in chaotic flows, *Phys. Fluids A*, **5**, 1417-1430 (1991).
- F.J. Muzzio, P.D. Swanson, and J.M. Ottino, The statistics of stretching and stirring in chaotic flows, *Phys. Fluids A*, **5**, 822-834 (1991).
- T.J. Danielson, F.J. Muzzio, and J.M. Ottino, Aggregation and structure formation in chaotic and regular flows, *Phys. Rev. Lett.*, **66**, 3128-3131 (1991).
- K. Shariff, T.H. Pulliam, and J.M. Ottino, A dynamical systems analysis of kinematics in the time-periodic wake of a circular cylinder, *Lectures in Applied Mathematics*, **28**, 613-646 (1991).
- J.G. Franjione and J.M. Ottino, Stretching in duct flows, *Phys. Fluids A*, **3**, 2819-2821 (1991); *erratum*, *Phys. Fluids*, **6**, 3501 (1991).
- M. Tjahjadi and J.M. Ottino, Stretching and breakup of droplets in chaotic flows, *J. Fluid Mech.*, **232**, 191-219 (1991).
- F.J. Muzzio, M. Tjahjadi, and J.M. Ottino, Self-similar drop size distributions produced by breakup in chaotic flows, *Phys. Rev. Lett.*, **67**, 54-57 (1991).
- H.A. Kusch and J.M. Ottino, Experiments on mixing in continuous chaotic flows, *J. Fluid Mech.*, **236**, 319-348 (1992).

S.C. Jana and J.M. Ottino, Chaos-enhanced transport in cellular flows, *Proc. Roy. Soc. London A.*, **338**, 519-532 (1992). Also published in *Nonlinear Dynamics of Engineering Systems*, edited by J.M.T. Thompson and W. Schliehler, London: The Royal Society (1992).

F.J. Muzzio, P.D. Swanson, and J.M. Ottino, Mixing distributions produced by multiplicative stretching in chaotic flows, *Int. J. Chaos and Bifurcations*, **2**, 37-50 (1992) (cover article).

J.G. Franjione and J.M. Ottino, Symmetry concepts for the geometric analysis of mixing flows, *Phil. Trans. Roy. Soc. Lond.*, **338**, 301-323 (1992).

F.J. Muzzio, C. Meneveau, P.D. Swanson, and J.M. Ottino, Scaling and multifractal properties of mixing in chaotic flows, *Phys. Fluids A*, **4**, 1439-1456 (1992).

J. M. Ottino, F. J. Muzzio, M. Tjahjadi, J. G. Franjione, S. C. Jana, H. A. Kusch, Chaos, Symmetry, and self-similarity: Exploiting order and disorder in mixing processes, *Science*, **257**, 754-760 (1992).

M. Tjahjadi, H.A. Stone, and J.M. Ottino, Satellite and sub-satellite formation in capillary breakup, *J. Fluid Mech.*, **243**, 297-317 (1992).

T. Shinbrot and J.M. Ottino, Geometric method to create coherent structures in chaotic flows, *Phys. Rev. Lett.*, **71**, 843-846 (1993).

T.C. Niederkorn and J.M. Ottino, Mixing of viscoelastic fluids in time-periodic flows, *J. Fluid Mech.* **256**, 243-268 (1993).

J.M. Ottino, S.C. Jana, and V.J. Chakravarthy, From Reynolds's stretching and folding to mixing studies using horseshoe maps, *Phys. Fluids A.*, **6**, 685-699 (1994).

M. Tjahjadi, H.A. Stone, and J.M. Ottino, Estimating interfacial tension via relaxation of drops shapes and filament breakup, *AIChE Journal*, **40**, 385-394 (1994).

G. Metcalfe and J.M. Ottino, Autocatalytic processes in chaotic flows, *Phys. Rev. Lett.*, **72**, 2875-2878 (1994); erratum, *Phys. Rev. Lett.*, **73**, 21 (1994).

S.C. Jana, G. Metcalfe, and J.M. Ottino, Experimental and computational studies of mixing in complex Stokes flows: The vortex mixing flow and multicellular cavity flows, *J. Fluid Mech.* **256**, 199-246 (1994).

S.C. Jana, M. Tjahjadi, and J.M. Ottino, Chaotic mixing of viscous fluids by periodic changes of geometry: The baffle-cavity system, *AIChE Journal*, **40**, 1769-1781 (1994).

T.C. Niederkorn and J.M. Ottino, Mixing of shear thinning fluids in time-periodic flows, *AIChE Journal*, **40**, 1782-1793 (1994).

J.M. Ottino, Mixing and chemical reactions: A tutorial, *Chem.Eng. Sci.* **49** (24A), 4005-4027 (1994).

T. Shinbrot and J.M. Ottino, Maps, PDE's and solitary waves, *Int. J. Bifur. Chaos*, **5**, 955-970 (1995).

- G. Metcalfe, J.M. Ottino, C.R. Bina, Kinematical considerations for mantle mixing, *Geophys. Rev. Lett.*, **22**, 743-746 (1995).
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- G. Metcalfe, T. Shinbrot, J.J. McCarthy, and J.M. Ottino, Avalanche mixing of granular materials, *Nature*, **374**, 39-41 (1995) (cover article).
- V.J. Chakravarthy and J.M. Ottino, Mixing studies using horseshoes, *Int. J. Bifurcation and Chaos*, **5**, 519-530 (1995).
- J. M. Ottino, A. Souvaliotis, and G. Metcalfe, Chaotic mixing processes: New problems and computational issues, *Chaos, Solitons, and Fractals*, **6**, 425-438 (1995).
- S. Hansen and J.M. Ottino, Agglomerate Erosion: A non-scaling solution to the fragmentation equation, *Phys. Rev. E*, **53**, 4209-4212 (1996).
- S. Hansen and J.M. Ottino, Aggregation and cluster size evolution in non-homogenous flows, *J. Colloid and Int. Sci.*, **179**, 89-103 (1996).
- V.J. Chakravarthy and J.M. Ottino, Mixing of two viscous fluids in a rectangular cavity, *Chem. Eng. Sci.*, **51**, 3613-3622 (1996).
- L. Bresler, T. Shinbrot, and J.M. Ottino, Control of transport in chaotic lattice, *Physica D*, **93**, 191-209 (1996).
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- L. Bresler, T. Shinbrot, G. Metcalfe, and J.M. Ottino, Isolated mixing regions: Origin, robustness, and control, *Chem. Eng. Sci.* **52**, 1623-1639 (1997).
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- S. Hansen and J.M. Ottino, Fragmentation with abrasion and cleavage: Analytical results, *Powder Tech.* **93**, 177-184 (1997).
- D.V. Khakhar, J.J. McCarthy, T. Shinbrot, and J.M. Ottino, Transverse flow and mixing of granular materials in a rotating cylinder, *Phys. Fluids*, **9**, 31-43 (1997).
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- J.M. Ottino, Kinematical views of mixing of fluids and granular materials: A brief review and open questions, *Rev. Mex. Fis.* **44**: (3) 215-221 (1998).
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- G.O. Fountain, D.V. Khakhar, and J.M. Ottino, Visualization of three-dimensional chaos, *Science*, **281**, 683-686 (1998) (cover article).
- M. Horner, W.M. Miller, J.M. Ottino, and E.T. Papoutsakis, Transport in grooved perfusion flat-bed bioreactor for cell therapy applications, *Biotechnology Progress*, **14**, 689-698 (1998).
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20th International Symposium of Theoretical and Applied Mechanics (*plenary presentation*)
2nd Experimental Chaos Conference, Washington, DC (*plenary presentation*)
3M Center, Process Research and Technology, Division Engineering, St. Paul, Minnesota
3M Technical Forum, 3M Technical Center, Corporate Research Laboratory, St. Paul, MN
Abbott Laboratories
Alcoa Technical Center, Pennsylvania
Allied-Signal/UOP Research Center, des Plaines, Illinois
American Institute of Chemical Engineers
American Physical Society
Amherst College, Department of Physics
ANTEC/SPE - New Technology Forum, San Francisco, California
Argonne National Laboratory, DOE Nanotechnology symposium
AT&T Bell Laboratories, Murray Hill, NJ
Asia University, Taiwan
BF Goodrich, Cleveland
Boeing Leadership Center, Saint Louis
Boston University, Center for Polymer Studies and Department of Physics, Boston, Massachusetts
Brooklyn Polytechnic, Office Interdisciplinary Studies
Brown University, Providence, Rhode Island, Division of Engineering
California Institute of Technology, Pasadena, California, Department of Chemical Engineering
California Institute of Technology, Pasadena, California, Fluid Mechanics Seminars
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Chaos '89, sponsored by the American Physical Society, University of Rhode Island
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Cornell University, Center for Applied Mathematics/Department of Theoretical and Applied Mechanics
University of California, Berkeley, Applied Mechanics Division of A.S.M.E. and Society for Engineering Science
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DSM Research, Geleen, The Netherlands (series of five lectures)
Duke University, Center for Nonlinear and Complex Systems
Dutch Foundation for Chemical Research, Eindhoven, The Netherlands
E.I. du Pont de Nemours & Co, Experimental Station, Wilmington, DE
E.I. du Pont, Kingston, North Carolina

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University of Minnesota, Chemical Engineering and Materials Science, Minneapolis, Minnesota
Eastman Kodak Research Laboratories, Rochester, New York
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EPRI Workshop on Application of Chaos, San Francisco, California
Florida Atlantic University (Sigma Xi Lecture)
General Electric Company, Polymer Physics and Engineering, Corporate Research and Development,
Schenectady, New York
General Electric Company, Research and Development Center, Schenectady, NY
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Harvard University, Division of Applied Sciences and Engineering
Hong Kong University
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Indian Institute of Technology, Bombay
INTEC, Santa Fe, Argentina (series of seven two-hour lectures sponsored by the Inter American Bank)
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Johns Hopkins University, Chemical Engineering Department
KAIST, Korea
Lacey Lectures, California Institute of Technology, Pasadena, California
Levich Institute, City College, University of New York, New York, New York
Lehigh University, Bethlehem, Pennsylvania.
Los Alamos National Laboratories, Physics-Theory Seminars
Louisiana State University, Department of Chemical Engineering,
Massachusetts Institute of Technology, Department of Chemical Engineering, Cambridge, Massachusetts
Xerox Research Centre of Canada, Mississauga, Ontario, Canada
Merck and Co., West Point, Pennsylvania
Merck Sharp & Dohme Lectures, Department of Chemical Engineering, University of Puerto Rico,
Mayagüez, Puerto Rico
Michigan State University/University of Michigan, combined seminar, Departments of Chemical
Engineering
Mobil Chemical Company, Edison Research Center, New Jersey
Nanyang Technical University, Singapore
National Bureau of Standards, Chemical Engineering and Metrology Division, Gaithersburg, Maryland
National Bureau of Standards, Fluid Mechanics Division, Gaithersburg, Maryland
National Bureau of Standards, Polymer Science and Standards Group, Gaithersburg
NATO Workshop in Mixing, Cargèse, Corsica, France
North Carolina State University, Raleigh, Department of Chemical Engineering,
Northwestern University, Department of Mathematics
Oak Ridge Sigma Xi Chapter (Sigma Xi Lecture)
Oak Ridge, AIChE Section
Ohio State University, Chemical Engineering
Oxford, St. Catherine's College
Penn State University, The Robb Lecture in Chemical Engineering Science, Department of Chemical
Engineering and Materials Science
PLAPIQUI, Universidad Nacional del Sur, Bahia Blanca, Argentina, sponsored by the Interamerican
Development Bank
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Princeton University, Applied Mathematics
Princeton University, Department of Chemical Engineering
Princeton University, School of Engineering and Applied Sciences
Procter and Gamble Company, Cincinnati, Ohio
Purdue University, West Lafayette, Indiana, School of Chemical Engineering

Raychem Corporation, Menlo Park, California
Rensselaer Polytechnic Institute, Department of Chemical Engineering
Rohm & Haas Company, Research Laboratories, Bristol, Pennsylvania
Royal Institution, Danckwerts Memorial Lecture, London
Royal Danish Academy of Sciences and Letters
Rutgers State University, Department of Chemical & Biochemical Engineering
Shell Development Company, Westhollow Research Center, Houston, Texas
Sigma Xi Research Society Annual Meeting, University of Puerto Rico, Mayagüez, Puerto Rico
Sigma Xi Spring Lecture, Northwestern University
Stanford University, Paul Flory Symposium
Stanford University, Center for Turbulence Research
Stanford University, Department of Chemical Engineering
Stanford University, Department of Chemical Engineering, Stanford, California
Stanford University, Seminar in Fluid Mechanics
Stanford University, Stanford, Summer Course, Center for Turbulence Research, Department of Mechanical Engineering
State University of New York at Buffalo, Chemical Engineering
Symposium on Contemporary Applications of Mathematics, The Five College Applied Mathematics Program, Mount Holyoke College, South Hadley, Massachusetts
Syracuse University, Department of Chemical Engineering
Tennessee Eastman, Kingsport, Tennessee
Terex, Westport, Connecticut
Texas A&M University, College Station, Department of Chemical Engineering
The Johns Hopkins University, Chemical Engineering
The Pennsylvania State University, Department of Chemical Engineering
The University of Akron, Department of Chemical Engineering,
Tufts University, Department of Chemical Engineering, Medford, Massachusetts
Tulane University, Chemical Engineering
UCLA, Department of Chemical Engineering
Unilever Research, Port Sunlight, UK
Unilever, Colworth, UK
Unilever, Port Sunlight, England
Unilever, Trumbull, Connecticut
Union Carbide Corporation, Bound Brook, New Jersey
Union Carbide Corporation, Weston Canal Center, Somerset, NJ
University of Akron, Department of Chemical Engineering
University of Akron, Department of Polymer Engineering
University of Arizona, Chemical Engineering
University of California at Irvine (Aerospace Engineering)
University of California at Irvine (Chemical and Biochemical Engineering)
University of California at Los Angeles, Department of Chemical and Nuclear Engineering
University of California Davis, Department of Chemical Engineering, Davis, California
University of California, Berkeley, Department of Chemical Engineering,
University of California, Berkeley, Mechanical Engineering
University of California, Davis, Department of Chemical Engineering,
University of California, Los Angeles, Department of Chemical Engineering
University of California, Santa Barbara, Chemical Engineering
University of California, Santa Barbara, Department of Chemical and Nuclear Engineering
University of Cambridge, Applied Mathematics and Theoretical Physics
University of Cambridge, Chemical Engineering
University of Chicago (James Frank Institute)
University of Cincinnati, Department of Chemical Engineering
University of Colorado (Boulder), Chemical Engineering
University of Delaware, Department of Chemical Engineering
University of Florida

University of Hawaii, Department of Oceanography, School of Earth Science and Oceanography
 Northwestern University, Department of Physics
 University of Houston, Department of Chemical Engineering,
 University of Illinois at Chicago, Chemical Engineering
 University of Illinois at Urbana-Champaign, Chemical Engineering
 University of Illinois at Urbana-Champaign, Workshop on Scientific Issues in Multiphase Flows
 University of Illinois, Chemical Engineering, Chicago
 University of Illinois, Chicago
 University of Massachusetts, Amherst, Condensed Matter Seminars, Department of Physics and Astronomy
 University of Massachusetts, Amherst, Department of Food Engineering
 University of Massachusetts, Amherst, Department of Physics
 University of Massachusetts, Amherst, Department of Polymer Science and Engineering
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 Mathematics
 University of Massachusetts, Amherst, Massachusetts, Department of Polymer Science and Engineering
 University of Michigan, Department of Chemical Engineering,
 University of Michigan, Department of Mechanical Engineering and Applied Mechanics
 University of Minnesota, Chemical Engineering and Materials Sciences
 University of Minnesota, Department of Aerospace and Mechanics (Mechanics Seminars), Minneapolis,
 Minnesota
 University of Minnesota, Institute for Mathematics and its Applications
 University of Minnesota, Minneapolis, Department of Chemical Engineering and Materials Science
 University of Notre Dame, Department of Chemical Engineering
 University of Notre Dame, Reilly Lectures
 University of Pennsylvania, Department of Chemical Engineering
 University of Pittsburgh, Chemical and Petroleum Engineering
 University of South Carolina, “Images in Nanotechnology” Conferences
 University of South Carolina, Chemical Engineering
 University of Southern California, Department of Chemical Engineering
 University of Tennessee, Department of Chemical Engineering
 University of Texas, Austin, Department of Chemical Engineering
 University of Texas, Austin, Nonlinear Dynamics
 University of Vermont, Dean’s Distinguished Lecture
 University of Virginia, Chemical Engineering
 University of Washington, Seattle, Department of Chemical Engineering
 University of Wisconsin, Madison, Department of Chemical Engineering
 Washington University, Department of Chemical Engineering
 World Congress of Chemical Engineering (*plenary*), Glasgow, Scotland
 XL National Congress of Physics; Monterrey, Mexico (*plenary talk*)
 Yale University, Department of Mechanical Engineering

Consulting

3M (1994-2000), DSM, Netherlands (1992-1998), Rohm & Haas (1993), Gardner, Carton & Douglas (1994), B.F. Goodrich (1996-97), Unilever (1997-2008), Helene Curtis (1997), Intellicoat (1998), Dow Chemical (2000-2004), Merck (2000), Abbott (2001), Baxter (2002-3), Resodyn Corp. (2004-), SC Johnson (2004), Brookwood Pharmaceuticals (2006), Swagelok (2008), AkzoNobel (2010-2014).

Funding and Advising

Supervised 50 Ph.D. students – from chemical engineering, mechanical engineering, polymer science, physics, and applied mathematics – currently working in industry and academia (of these 30 have been singly advised by JMO). Federal funding sources have included NSF, DOE, AFOSR, and the U.S. Army. Industrial sources have included ALCOA, 3M, Exxon, Xerox, Dow Chemical, Owens Corning, Union Carbide, Rohm & Haas, du Pont, and others. Other sources have included The Petroleum Research Fund and the Dreyfus Foundation. Current PI in two NSF grants.

