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Microbiology & Immunology
Stanford University School of Medicine
(43 pages)

TITLE: Professor of Microbiology & Immunology

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US CITIZEN

EDUCTAION

Ph.D., April 1969 –Microbiology; University of California, Los Angeles

EMPLOYMENT

On Stanford faculty since 1975

Current Stanford academic appointments:

Full Professor (emeritus as of July 1, 2021):

- Department of Microbiology and Immunology
- Cancer Institute
- Program in Genetic and Molecular Medicine
- Aortic & Vulvular and Vascular Biology, Cardiovascular Institute
- Institute for Immunity, Transplantation and Infection
- BioX Program
- Woods Environmental Institute

Completed Stanford academic appointment

1989 - 1998: Professor, Western Region Hazardous Substance Research Center,
Stanford University

Employment prior to Stanford

1971 - 1975 Scientific Officer, First Class
Department of Microbiology
State University of Groningen
Haren (Gr.), The Netherlands

1964 - 1971 Teaching or Research Assistant ('64-'69)
Postdoctoral Research Associate ('69-'71)
Department of Microbiology
University of California, Los Angeles
Los Angeles, California 90024

1962 -1964 Lecturer, St. Joseph's College for Women

PROFESSIONAL SOCIETIES

- American Association for Cancer Research
- International Society of Extracellular vesicles (ISEV)
- American Association of Gene Therapy
- American Society for Clinical Oncology
- American Chemical Society
- American Society for Microbiology
- Biophysical Society
- American Association for the Advancement of Science
- International Society for Microbial Ecology
- Society for Industrial Microbiology
- New York Academy of Sciences
- American Aerospace Medical Association
- American Society for Gravitational and Space Biology
- European Low Gravity Research Association
- Society of the Sigma Xi
- American Association of University Professors

HONORS/PROFESSIONAL RECOGNITION

- M.S. (1962) & Ph. D. degrees with distinction
- Fulbright Scholar: 1964-1971
- Member: Stanford Recombinant DNA Panel: 1983-84
- Chair: Stanford Recombinant DNA Panel: 1984-85
- Board Member, Northern Branch of the Society for Industrial Microbiology: 1990-1991
- Two times recipient of Environmental Protection Agency's Star Award:
August 1991, and August 1995 (#R823390)
- ASM Foundation for Microbiology Lecturer: 1991-1993

- Member: Stanford Biosafety Committee: 1992-1994
- Review Committee of the Accreditation Board for Engineering and Technology (ABET) 1992 –94
- Elected Fellow, American Academy of Microbiology (elected in 1995)
- Board Member for developing of Department of Energy plan for “Natural and Accelerated Bioremediation Research (NABIR),” 1998.
- Member Stanford Institutional Review Board: 2005 – 2007
- Departmental representative to Stanford Medical School Senate: 2006 - 2011
- Elected to the Steering Committee of Stanford Medical School Senate, 2008 – 2011
- Chair, Medical School Senate Task Force for Postdoctoral Affairs, 2010 – 2011
- Elected Associate Fellow, American Aerospace Medical Association (AsMA): 2011
- Chair Reception Committee, American Aerospace Medical Association: 2012
- Honorary Editorial Board Member, London Journals Press; editor of several other Journals
- Recipient of NASA honor award as PI of ECAMSAT Project (see publications #85, 89, 92, 91)
- Entry in Encyclopedia.com
- Entry in Wikipedia
- Designed experiments as P.I. that led NASA to sponsor space flight to test measures for astronaut safety

PUBLICATIONS

A. Original Papers

1. **Matin, A.**, and S.C. Rittenberg. 1970. Utilization of glucose in heterotrophic media by *Thiobacillus intermedius*. *Journal of Bacteriology*, **104**:234-238.
2. **Matin, A.**, and S.C. Rittenberg. 1970. Regulation of glucose metabolism in *Thiobacillus intermedius*. *Journal of Bacteriology*, **104**:239-246.
3. **Matin, A.**, and S.C. Rittenberg. 1971. Enzymes of carbohydrate metabolism in *Thiobacillus* species. *Journal of Bacteriology*, **107**:179-186.
4. Lu, M.C., **A. Matin**, and S.C. Rittenberg. 1971. Inhibition of growth of obligately chemolithotrophic *Thiobacilli* by amino acids. *Archive of Microbiology*, **79**:354-366.
5. **Matin, A.**, and S.C. Rittenberg. 1972. Kinetics of deoxyribonucleic acid destruction and synthesis during growth of *Bdellovibrio bacteriovorus* strain 109D in *Pseudomonas putida* and *Escherichia coli*. *Journal of Bacteriology*, **111**:664-673.
6. **Matin, A.**, and W.N. Konings. 1973. Transport of lactate and succinate by membrane vesicles of *Escherichia coli*, *Bacillus subtilis* and a *Pseudomonas* species. *European Journal of Biochemistry*, **34**:58-67.
7. **Matin, A.**, W.N. Konings, J.G. Kuenen, and M. Emmens. 1974. Active transport of amino acids by membrane vesicles of *Thiobacillus neapolitanus*. *Journal of General Microbiology*, **83**:311-318.

8. Harder, W., **A. Matin**, and M.M. Attwood. 1975. Studies on the physiological significance of the lack of a pyruvate dehydrogenase complex in *Hyphomicrobium* sp. *Journal of General Microbiology*, **86**:319-326.
9. **Matin, A.**, A. Grootjans, and H. Hogenhuis. 1976. Influence of dilution rate on enzymes of intermediary metabolism in two freshwater bacteria grown in continuous culture. *Journal of General Microbiology*, **94**:323-332.
10. **Matin, A.**, and J.C. Gottschal. 1976. Influence of dilution rate on NAD(P) and NAD(P)H concentrations and ratios in a *Pseudomonas* sp. grown in continuous culture. *Journal of General Microbiology*, **94**:333-341.
11. **Matin, A.**, and H. Veldkamp. 1978. Physiological basis of the selective advantage of a *Spirillum* sp. in a carbon-limited environment. *Journal of General Microbiology*, **105**:187-197.
12. Masover, G.K., R. Perez, and **A. Matin**. 1979. Cultivation of *Ureaplasma urealyticum* in continuous culture. *Infection & Immunity*, **23**:175-177.
13. **Matin, A.**, C. Veldhuis, V. Stegeman, and M. Veenhuis. 1979. Selective advantage of a *Spirillum* sp. in a carbon-limited environment: accumulation of poly- β -hydroxybutyric acid and its role in starvation. *Journal of General Microbiology*, **112**:349-355.
14. **Matin, A.**, F.J. Kahan, and R. Leefeldt. 1980. Growth factor requirement of *Thiobacillus novellus*. *Archives of Microbiology*, **124**:91-95.
15. Perez, R.C., and **A. Matin**. 1980. Growth of *Thiobacillus novellus* on mixed substrates (mixotrophic growth). *Journal of Bacteriology*, **142**:633-638.
16. **Matin, A.**, M. Schleiss, and R.C. Perez. 1980. Regulation of glucose transport and metabolism in *Thiobacillus novellus*. *Journal of Bacteriology*, **142**:639-644.
17. Leefeldt, R.H., and **A. Matin**. 1980. Growth and physiology of *Thiobacillus novellus* under nutrient-limited mixotrophic conditions. *Journal of Bacteriology*, **142**:645-650.
18. **Matin, A.**, and M.K. Matin. 1982. Cellular levels, excretion, and synthesis rates of cyclic AMP in *Escherichia coli* grown in continuous culture. *Journal of Bacteriology*, **149**:801-807.
19. Perez, R.C., and **A. Matin**. 1982. Carbon dioxide assimilation by *Thiobacillus novellus* under nutrient-limited mixotrophic conditions. *Journal of Bacteriology*, **150**:46-51.
20. **Matin, A.**, B. Wilson, E. Zychlinsky, and M. Matin. 1982. Proton motive force and the physiological basis of Δ pH maintenance in *Thiobacillus acidophilus*. *Journal of Bacteriology*, **150**:582-591.
21. Berg, J.D., **A. Matin**, and P.V. Roberts. 1982. Effect of antecedent growth conditions on sensitivity of *Escherichia coli* to chlorine dioxide. *Applied & Environmental Microbiology*, **44**:814-819.
22. **Matin, A.**, and M.K. Matin. 1982. The protonmotive force and the Δ pH in spheroplasts of an acidophilic bacterium (*Thiobacillus acidophilus*). *Journal of General Microbiology*, **128**:3071-3075.

23. Zychlinsky, E., and **A. Matin**. 1983. Effect of starvation on cytoplasmic pH, proton motive force, and viability of an acidophilic bacterium, *Thiobacillus acidophilus*. *Journal of Bacteriology*, **153**:371-374.
24. Zychlinsky, E., and **A. Matin**. 1983. Cytoplasmic pH homeostasis in an acidophilic bacterium, *Thiobacillus acidophilus*. *Journal of Bacteriology*, **156**:1352-1355.
25. Abou-Shleib, H., J.D. Berg, and **A. Matin**. 1983. Effect of antecedent growth conditions on sensitivity of *Escherichia coli* to phenylphenol. *FEMS Microbiology Letters*, **19**:183-186.
26. Reeve, C.A., A. Bockman, and **A. Matin**. 1984. Role of protein degradation in the survival of carbon-starved *Escherichia coli* and *Salmonella typhimurium*. *Journal of Bacteriology*, **157**:758-763.
27. Reeve, C.A., P.S. Amy, and **A. Matin**. 1984. Role of protein synthesis in the survival of carbon-starved *Escherichia coli* K-12. *Journal of Bacteriology*, **160**:1041-1046.
28. Inloes, D., **A. Matin**, A.S. Michaels, and C.R. Robertson. 1985. Ethanol production by nitrogen-deficient yeast cells immobilized in a hollow-fiber membrane bioreactor. *Applied Microbiology and Biotechnology*, **23**:85-91.
29. Harakeh, M.S., J. Berg, J.C. Hoff, and **A. Matin**. 1985. Susceptibility of chemostat-grown *Yersinia enterocolitica* and *Klebsiella pneumoniae* to chlorine dioxide. *Applied & Environmental Microbiology*, **49**:69-72.
30. Berg, D.B., J.C. Hoff, P.V. Roberts, and **A. Matin**. 1985. Disinfection resistance of *Legionella pneumophila* and *Escherichia coli* grown in continuous and batch cultures. *In Water Chlorination*, Vol. 5, (eds.) R.L. Jolley, et al., **Ann Arbor Science Publishers**, Michigan. **pp. 603-613**.
31. Berg, J.D., J.C. Hoff, P.V. Roberts, and **A. Matin**. 1985. Growth of *Legionella pneumophila* in continuous culture. *Applied & Environmental Microbiology*, **49**:1534-1537.
32. Bockman A., C.A. Reeve, and **A. Matin**. 1986. Stabilization of glucose starved *Escherichia coli* K-12 and *Salmonella typhimurium* LT2 by peptidase deficient mutants. *Journal of General Microbiology*, **132**:231-235.
33. Goulbourne, Jr., E., M. Matin, E. Zychlinsky, and **A. Matin**. 1986. Mechanism of Δ pH maintenance in active and inactive cells of an obligately acidophilic bacterium. *Journal of Bacteriology*, **166**:59-65.
34. Groat, G. and **A. Matin**. 1986. Synthesis of unique proteins at the onset of carbon starvation in *Escherichia coli*. *Journal of Industrial Microbiology*, **1**:69-73.
35. Groat, R.G., J. Schultz, E. Zychlinsky, A. Bockman, and **A. Matin**. 1986. Starvation proteins in *Escherichia coli*: kinetics of synthesis and role in starvation survival. *Journal of Bacteriology*, **168**:486-493.
36. Berg, J.D., P.V. Roberts, and **A. Matin**. 1986. Effect of chlorine dioxide on selected membrane functions of *Escherichia coli*. *Journal of Applied Bacteriology*, **60**:213-220.

37. Read, D.L., and **A. Matin**. 1987. Two-dimensional gel resolution of polypeptides specific for autotrophic growth in *Thiobacillus versutus*. *Journal of Applied Bacteriology*, **63**:469-472.
38. Harakeh, S., A. Illescas, and **A. Matin**. 1988. Inactivation of bacteria by purogene. *Journal of Applied Bacteriology*, **64**:459-463.
39. Schultz, J.E., G.I. Latter, and **A. Matin**. 1988. Differential regulation by cyclic AMP of starvation proteins in *Escherichia coli*. *Journal of Bacteriology*, **170**:3903-3909.
40. Jenkins, D.E., J.E. Schultz, and **A. Matin**. 1988. Starvation-induced cross protection against heat or H₂O₂ challenge in *Escherichia coli*. *Journal of Bacteriology*, **170**:3910-3914.
41. Berg, J.D., J.C. Hoff, P.V. Roberts, and **A. Matin**. 1988. Resistance of bacterial subpopulations to disinfection by chlorine dioxide. *Journal of American Water Works Association*, **Sept.**:115-119.
42. Harakeh, S., and **A. Matin**. 1989. Influence of nutrient-limited growth on outer-membrane proteins of *Yersinia enterocolitica*. *Journal of Applied Bacteriology*, **67**:209-212.
43. McLaggan, D., S. Belkin, L. Packer, and **A. Matin**. 1989. Electron spin resonance measurements of the effect of ionophores on the transmembrane pH gradient of an acidophilic bacterium. *Archives of Biochemistry*, **273**:206-214.
44. McLaggan, D., M. Keyhan, and **A. Matin**. 1990. Chloride transport pathways and their bioenergetic implications in the obligate acidophile, *Bacillus coagulans*. *Journal of Bacteriology*, **172**:1485-1490.
45. Jenkins, D.E., S. Chaisson, and **A. Matin**. 1990. Starvation-induced cross protection against osmotic challenge in *Escherichia coli*. *Journal of Bacteriology*, **172**:2779-2781.
46. **Matin, A.** 1990. Bioenergetics parameters and transport in obligate acidophiles. *Biochimica Biophysica Acta*, **1018**:267-270.
47. **Matin, A.** 1990. Molecular analysis of the starvation stress in *E. coli*. **FEMS Microbiology and Ecology**, **74**:185-96.
48. **Matin, A.** 1991. The molecular basis of carbon starvation-induced general resistance in *E. coli*. **Molecular Microbiology**, **5**:3-11.
49. Blum, P.H., S.B. Jovanovich, M.P. McCann, J.E. Schultz, S.A. Lesley, R.R. Burgess, and **A. Matin**. 1991. Cloning and in vivo and in vitro regulation of cyclic AMP-dependent carbon starvation genes from *Escherichia coli*. *Journal of Bacteriology*, **172**:3813-3820.
50. Schultz, J., and **A. Matin**. 1991. Molecular and functional characterization of a carbon starvation gene of *Escherichia coli*. *Journal of Molecular Biology*, **218**:129-140.
51. Jenkins, D.E., E. Auger, and **A. Matin**. 1991. Role of RpoH, a heat shock regulator protein, in *Escherichia coli* carbon starvation protein synthesis and survival. *Journal of Bacteriology*, **173**:1992-1996.

52. McCann, M.P., J.P. Kidwell, and **A. Matin**. 1991. The putative sigma factor KatF has a central role in the development of starvation-mediated general resistance in *Escherichia coli*. *Journal of Bacteriology*, **173**:4188-4194.
53. Blom, T., W. Harder, and **A. Matin**. 1992. Unique and overlapping pollutant stress proteins of *E. coli*. *Applied & Environmental Microbiology*, **58**:331-334.
54. Blum, P., M. Velligan, N. Lin, and **A. Matin**. 1992. DnaK-mediated alterations in human growth hormone protein inclusion bodies. *Bio/Technology*, **10**:301-304.
55. Tunner, J.R., C.R. Robertson, S. Schippa, and **A. Matin**. 1992. Use of glucose starvation to limit growth and induce protein production in *Escherichia coli*. *Biotechnology and Bioengineering*, **40**:271-279.
56. Blaisdell, B.E., K.E. Rudd, **A. Matin**, and S. Karlin. 1993. Significant dispersed recurrent DNA sequences in the *Escherichia coli* genome: several new groups. *Journal of Molecular Biology*, **229**:833-848.
57. McCann, M.P., C. Fraley, and **A. Matin**. 1993. The putative sigma factor, KatF, is regulated post-transcriptionally during carbon starvation. *Journal of Bacteriology*, **175**:2143-2149.
58. Kunji, E.R.S., T. Ubbink, **A. Matin**, B. Poolman, and W.N. Konings. 1993. Physiological responses of *Lactococcus lactis* ML3 to alternating conditions of growth and starvation. *Archives of Microbiology*, **159**:372-379.
59. **Matin, A.** 1994. Starvation promoters of *Escherichia coli*: their function, regulation & use in bioprocessing and bioremediation. *Recombinant DNA Technology II, Annals of New York Academy of Sciences*, **722**:277-291.
60. Lomovskaya, O.L., J.P. Kidwell, and **A. Matin**. 1994. Characterization of the σ^{38} -dependent expression of a core *Escherichia coli* starvation gene, *pexB*. *Journal of Bacteriology*, **176**:3928-3935.
61. Kim, Y., L. Watrud, and **A. Matin**. 1995. A carbon starvation survival gene of *Pseudomonas putida* is regulated by σ^{54} . *Journal of Bacteriology*, **177**: 1850-1859.
62. Lomovskaya, O., K. Lewis, and **A. Matin**. 1995. EmrR is a negative regulator of the *Escherichia coli* Multidrug Resistance Pump EmrAB. *Journal of Bacteriology*, **177**:2328-2344.
63. **Matin, A.**, C.D. Little, C.D. Fraley, and M. Keyhan. 1995. Use of starvation promoters to limit growth and selectively express trichloroethylene and phenol transformation activity in recombinant *Escherichia coli*. *Applied and Environmental Microbiology*, **61**:3323-3328.
64. **Matin, A.**, E. Zychlinsky, M. Keyhan, and G. Sachs. 1996. The capacity of *Helicobacter pylori* to generate ionic gradients at low pH is similar to that of bacteria which grow under strongly acidic conditions. *Infection & Immunity* **64**:1434-1436.
65. Lomovskaya, O., F. Kawai, and **A. Matin**. 1996. Differential regulation of *MCB* and *EMR* operons: role of *MCB* in multidrug resistance. *Antimicrobial Agents & Chemotherapy* **40**:1050-1052.

66. Schweder, T., K. Lee, O. Lomovskaya, and **A. Matin**. 1996. Regulation of *Escherichia coli* starvation sigma factor (σ^S) by ClpXP protease. *Journal of Bacteriology* **178**: 470-476.
67. Zgurskaya, H., M. Keyhan, and **A. Matin**. 1997. The σ^S level in starving *Escherichia coli* cells increases solely as a result of its increased stability, despite decreased synthesis. *Molecular Microbiology*, **24**: 643-651.
68. Saier, M. H., I.T. Paulsen, and **A. Matin**. 1997. A bacterial model system for understanding multidrug resistance. **Microbial Drug Resistance**, **3**:289-295.
69. Ulitzur, S; **Matin, A**; Fraley, C; and E. Meighen. 1997. H-NS protein represses transcription of the *lux* systems of *Vibrio fischeri* and other luminous bacteria cloned into *Escherichia coli*. *Curr. Microbiol.* **35**:336-42.
70. Fraley, C.D., J.H. Kim, M.P. McCann, and **A. Matin**. 1998. The *Escherichia coli* starvation gene, *cstC*, is involved in amino acid catabolism. *Journal of Bacteriology*: **180**:4287-4290
71. Park, C-H., M. Keyhan, B. Wielinga, S. Fendorf, and **A. Matin**. 2000. Purification to homogeneity and characterization of a novel *Pseudomonas putida* chromate reductase. *Applied & Environmental Microbiology* **66**: 1788-1795
72. Pandza, S., M. Baetens, C-H. Park, T. Au, M. Keyhan, and **A. Matin**. 2000. The putative G-protein FLHF has a role in polar flagellar placement and general stress response induction in *Pseudomonas putida*. *Molecular Microbiology* **36**: 414-423 (*highlighted by the Journal on title page*).
73. Xiong, A. A. Gottman, C. Park, M. Baetons, S. Pandza, and **A. Matin**. 2000. The EmrR protein represses the *Escherichia coli* *emrRAB* multidrug resistance operon by directly binding to its promoter region. *Antimicrobial Agents and Chemotherapy* **44**: 2905-2907.
74. Stone, G., P. Wood, L. Dixon, M. Keyhan and **A. Matin**. 2002. Tetracycline rapidly reaches all the constituent cells of uropathogenic *Escherichia coli* biofilms. *Antimicrobial Agents and Chemotherapy* **46**: 2458-2461.
75. Gonzalez CF, Ackerley DF, Park CH, Keyhan M. and **Matin A**. 2002 A soluble flavoprotein contributes to chromate reduction and tolerance by *Pseudomonas putida*. *Acta Biotechnol.*, **23**: 233-239
76. Keyhan, M, D. F. Ackerley, and **A. Matin**. 2003. Targets of improvement in bacterial chromate bioremediation. *Remediation of Contaminated Sediments—2003. Proceedings of the Second International Conference on Remediation of Contaminated Sediments (Venice, Italy)*, M. Pellei and A. Porta (Eds.), **Battelle Press**, Columbus, OH, **E-06**, pp, 1-8
77. Ackerley, D.F., C.F. Gonzalez, C.H. Park, R. Blake II, M. Keyhan, and **A. Matin**. 2004. Chromate reducing properties of soluble flavoproteins from *Pseudomonas putida* and *Escherichia coli*. *Applied & Environmental Microbiology*, **70**: 873-882
78. Ackerley, D.F., C.F. Gonzalez, C.H. Park, R. Blake II, M. Keyhan, and **A. Matin**. 2004. Mechanism of chromate reduction by the *Escherichia coli* protein, NfsA, and the role of

different chromate reductases in minimizing oxidative stress during chromate reduction. *Environmental Microbiology*, **6**: 851-860

79. Lynch, S., E.L. Brodie, and **A. Matin**. 2004. Role and regulation of σ^S in low shear microgravity-conferred general resistance in *Escherichia coli*. *Journal of Bacteriology* **186**: 8207-8212
80. Gonzalez, C.F., D.F. Ackerley, S.V. Lynch, and **A. Matin**. 2005. ChrR, a soluble quinone reductase of *Pseudomonas putida* that defends against H₂O₂. *The Journal of Biological Chemistry*. **280**: 22590-22595.
81. Barak, Y., S.H. Thorne, D. F. Ackerley, S.V. Lynch, C.H. Contag, and **A. Matin**. 2006. New enzyme for reductive cancer chemotherapy (YieF) and its improvement by directed evolution. *Molecular Cancer Therapeutics* **5**: 97-103.
82. Ackerley, D.F., Y. Barak, S.V. Lynch, J. Curtin, and **A. Matin**. 2006. Effect of chromate stress on *Escherichia coli* K12. *Journal of Bacteriology* **188**: 3371-3381
83. Lynch, S.V., K. Mukundakrishnan, P. Ayyaswami, and **A. Matin**. 2006. *Escherichia coli* biofilms formed under low shear simulated microgravity in a ground-based system. *Applied & Environmental Microbiology* **72**: 7701-7710
84. Barak, Y., D. F. Ackerley, C. J. Dodge, B. Lal, A. Cheng, A. J. Francis, and **A. Matin**. 2006. Analysis of novel soluble Cr(VI) and U(IV) reductases and generation of improved enzymes using directed evolution. *Applied and Environmental Microbiology*, **72**: 7074-7082
85. Lynch, S.V., L. Dixon, M.R. Benoit, E.L. Brodie, M. Keyhan, P. Hu, D.F. Ackerley, G.L. Andersen and **A. Matin**. 2007. Role of the *rapA* gene in controlling antibiotic resistance of *Escherichia coli* biofilms. *Antimicrobial Agents and Chemotherapy* **51**: 3650 – 3658
86. Barak, Y., Y. Nov., D. Ackerley, and **A. Matin**. 2008. Enzyme improvement in the absence of structural knowledge - a novel approach. *ISME Journal*, **2**: 171-179
87. Thorne, S., Barak, Y., Liang, W., Bachmann, M.H., Rao, J., Contag, C., and **Matin, A.** CNOB/ChrR6. 2009. A new prodrug enzyme cancer chemotherapy. *Molecular Cancer Therapeutics* **8**: 333-341
88. Benoit, M.R., D. Mayer, Y. Barak, I.Y. Chen, W. Hu, Z. Cheng, S.X. Wang, D.M. Spielman, S.S. Gambhir, and **A Matin**. 2009. Visualizing implanted tumors in mice with MRI using magnetotactic bacteria. *Clinical Cancer Research* **15 (16)**: 5170 – 5177
89. Barak, Y., F. Schreiber, S.H. Thorne, C.H. Contag, D. deBeer, and **A Matin**. 2010. Role of nitric oxide in *Salmonella typhimurium*-mediated cancer cell killing. *BMC Cancer* **10**: 146-152
90. Benoit, M.R., Conant, C., Ionescu-Zanetti, C., Schwartz, M., and **Matin, A.** 2010. New device for high throughput viability screening of flow-biofilms. *Applied and Environmental Microbiology* **76 (13)**: 4136-4142.
91. Eswaramoorthy, S., Poulain, S., Hienerwadel, R., Bremond, N., Sylvester, M., Zhang, Y., Berthomieu, C., Van Der Lelie, D., **Matin, A.** 2012. Crystal structure of ChrR – A quinone reductase with the capacity to reduce chromate. *PLoS One*, April 2012 | Volume 7

92. J-H Wang, R Singh, M Benoit, M Keyhan, M Sylvester, M Hsieh, A Tathireddy, Y-J Hsieh, **AC Matin**. 2014. Sigma S-dependent antioxidant defense protects stationary phase *Escherichia coli* against the bactericidal antibiotic gentamicin. *Antimicrobial Agents Chemotherapy* 58(10): 5964-5975
93. Zhang H., Cohen A.L., Krishnakumar S., Wapnir I.L., Veeriah S., Deng G., Coram M.A., Piskun C.M., Longacre T.A., Herrler M., Frimannsson D.O., Telli M.L., Dirbas F.M., **Matin A.C.**, Dairkee S.H., Larijani B., Glinsky G.V., Bild A.H., Jeffrey S.S. 2014. Patient-derived xenografts of triple-negative breast cancer reproduce molecular features of patient tumors and respond to mTOR inhibition. *Breast Cancer Res.* 2014 Apr 7;16(2)
94. Kanada M, Bachmann MH, Hardy JW, Frimannsson DO, Bronsart L, Wang A, Sylvester MD, Schmidt TL, Kaspar RL, Butte MJ, **Matin AC**, Contag CH. 2015. Differential fates of biomolecules delivered to target cells via extracellular vesicles. *Proc Natl Acad Sci.* E1433–E1442
95. Wang JH, Endsley AN, Green C, **Matin AC**. 2016. Utilizing native fluorescence imaging, modeling and simulation to examine pharmacokinetics and therapeutic regimen of a novel anticancer prodrug. *BMC Cancer (2016)* 16:524 (DOI 10.1186/s12885-016-2508-6)
96. **AC Matin**, J-H Wang, Mimi Keyhan, Rachna Singh, Michael Benoit, Macarena P. Parra, Michael R. Padgen, Antonio J. Ricco, Matthew Chin, Charlie R. Friedericks, Tori N. Chinn, Aaron Cohen, Michael B. Henschke, Timothy V. Snyder, Matthew P. Lera, Shannon S. Ross, Christina M. Mayberry, Sungshin Choi, Diana T. Wu, Ming X. Tan, Travis D. Boone, Christopher C. Beasley, and Stevan M. Spremo. Payload hardware and experimental protocol for testing the effect of space microgravity on the resistance to gentamicin of stationary-phase uropathogenic *Escherichia coli* and its σ^S -deficient mutant. *Life Sciences in Space Research* 15: 1-10 (2017) — *High-lighted by the journal*
97. Wang, J H, Forterre A V, Zhao J, Frimannsson D O., Delcayre A, Antes T J, Efron B, Jeffrey S S, Pegram M D, **Matin A C**. 2018. Anti-HER2 scFv-directed extracellular vesicle-mediated mRNA-based gene delivery Inhibits growth of HER2-Positive human breast tumor xenografts by prodrug activation. *Molecular Cancer Therapeutics* 17 (5), 1133-1142 (**Editor's selection in *Science Translational Medicine***: <http://stm.sciencemag.org/content/10/433/eaat1642.full>)
98. Fengjiao Lyu, Ming Pan, Sunita Patil, Jing-Hung Wang, **A. C Matin**, Jason R Andrews, Sindy K.Y. Tang. 2018. Phenotyping antibiotic resistance with single-cell resolution for the detection of heteroresistance. *Sensors & Actuators: B. Chemical* 270 (2018) 396–404
99. Michael R. Padgen, Matthew P. Lera, Macarena P. Parra, Antonio J. Ricco, Matthew Chin, Tori N. Chinn, Aaron Cohen, Charlie R. Friedericks, Michael B. Henschke, Timothy V. Snyder, Stevan M. Spremo, Jing-Hung Wang, **AC Matin**. *EcAMSat* spaceflight measurements of the role of σ^S in antibiotic resistance of stationary phase *Escherichia coli* in microgravity. *Life Sciences in Space Research* 24 (2020) 18-24 (*Journal highlight*).
100. Alexis V. Forterre, Jing-Hung Wang, Alain Delcayre, Kyuri Kim, Carol Green, Mark D. Pegram, Stefanie S. Jeffrey, **A. C. Matin**. EV-mediated in vitro transcribed mRNA-based

gene delivery for targeted treatment of HER2⁺ breast cancer xenografts in mice by CB1954 without general toxicity. *Molecular Cancer Therapeutics*, Published Online, January 15, 2020; DOI: 10.1158/1535-7163.MCT-19-0928

B. Invited Review Articles/Book Chapters/Research Reports

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84. **A.C. Matin**, D. Ackerley, C. Gonzalez and Y. Barak. Engineering bacteria for superior Chromate bioremediation, Annual NABIR PI Meeting - April 18, 2005, Warrenton, VA
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86. Lynch, S., E. L. Brodie, and **A. Matin**. 2005. Molecular mechanisms underlying low-shear simulated microgravity increased stress resistance in planktonic and biofilm *Escherichia coli* cultures, 2005 NASA Cell Science Conference, Moody Gardens, Galveston, Texas. Abstract # 16
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104. Benoit, MR, **Matin, A.** New Methods for High Throughput Screening of Biofilms. American Society for Microbiology, 109th General Meeting. Philadelphia, PA. May18, 2009.
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113. Sebastien Poulain, Subramaniam Eswaramoorthy, Rainer Hienerwadel, Nicolas Bremond, Matthew D. Sylvester, Virginie Chapon, Catherine Berthomieu, and **A.C. Matin**. Molecular basis of ChrR improvement for metal and radionuclide bioremediation, EGU General Assembly 2011, Vienna, Australia, BG9
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117. **A.C. Matin**, A.J. Ricco, M. Parra, K. Ronzano, M. Lera, D. Wu, M. Tan, S. Ross, M. Keyhan, C. Mayberry, C. Beasley, and S. Choi. EcAMSat: Nanosatellite microfluidic payload determines spaceflight effects on bacterial antibiotic resistance and their

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 123. M Kanada, MH Bachmann, JW Hardy, L Bronsart, A Wang, DO Frimannsson, TL Schmidt, MJ Butte, **AC Matin**, CH Contag, Imaging of functional molecule transfer by tumor-derived microvesicles, World Molecular Imaging Congress 2014, Korea, Sep. 17-20, 2014
 124. Tori Chinn, Travis Boone, Matthew Chin, Aaron Cohen, Charlie Friedericks, Evan Jackson, Matthew Lera, **AC Matin**, Christopher Middour, Macarena Parra, Antonio Ricco, Stevan Spremo. EcAMSat Fluidic System: Lessons Learned for Reduced Gravity Biological Research. ASGSR; September 2014; Pasadena, CA. Session 10, October 25, 2014
 125. M Kanada, MH Bachmann, JW Hardy, L Bronsart, A Wang, DO Frimannsson, MD Sylvester, TL Schmidt, RL Kaspar, MJ Butte, **AC Matin**, CH Contag, Differential fates of biomolecules delivered to target cells via extracellular vesicles, American Society of Exosomes & Microvesicles 2014, Asilomar, Oct. 10-13, 2014
 126. Frimannsson DO, Sylvester M, Pegram M, Jeffrey S, Contag C, Delcayre, A and **Matin AC**. 2014. Specific delivery of cholesterol-tagged genetic material using HER2-targeted single-chain variable fragment (ScFv) exosomes. NIH Extracellular RNA Consortium 3rd Investigator's Meeting., #26; page 30
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128. **Matin AC**. Use of a new visualizable prodrug regimen for specific targeting of HER2 positive breast cancer using exosomes, ASEM2015 Marco Island Marriott Resort, Marco Island, Florida, October 16-20, 2015
129. M Kanada, MH Bachmann, JW Hardy, DO Frimannson, L Bronsart, A Wang, MD Sylvester, TL Schmidt, RL Kaspar, MJ Butte, **AC Matin**, CH Contag, Bioluminescence imaging reveals tissue specificity of extracellular vesicle-mediated biomolecule transfer *in vivo*, World Molecular Imaging Congress 2015, Hawaii, Sep. 2-5, 2015
130. Masamitsu Kanada, Michael H. Bachmann, Jonathan W. Hardy, Laura Bronsart, Andrew Wang, Daniel Omar Frimannson, Matthew D. Sylvester, Tobi L. Schmidt, Roger L. Kaspard, Manish J. Butte, **A.C. Matin**, Christopher H. Contag. Differential fates of biomolecules delivered to target cells via extracellular vesicles. exRNA Communication Consortium Investigators' Meeting, November 2015, Rockville, MD
131. Wang JH, Delcayre A, Antes TJ, Gupta A, Kanada M, Jeffrey S, Pegram M, Wilson C, Grant G, Contag C, **Matin AC**. Targeted extracellular vesicles to deliver a new prodrug regimen to HER2+ve breast cancer. exRNA Communication Consortium Investigators' Meeting Nov. 2015, Rockville, MD
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133. **A.C. Matin**, M. Benoit, M. Chin, T.N. Chinn, A. Cohen, C. Friedericks, M.B. Henschke, M. Keyhan, M.P. Lera, M.R. Padgen, M.P. Parra, A.J. Ricco, R. Singh, T. Snyder, S.M. Spremo, J. Wang. EcAMSat: Effect of Spaceflight on Antibiotic Resistance of a Pathogenic Bacterium and its Genetic Basis. ASGSR November 2015
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135. Harada M, Wang JH, Delcayre A, Kanada M, Contag CH, Jeffrey SS, **Matin AC**. Construction of dual-function extracellular vesicles for imaging, delivery and targeting in cancer therapy. NIH EERC April 2016 meeting, Bethesda, MD
136. Wang JH, Harada M, Delcayre A, Antes TJ, Gupta A, Kanada M, Jeffrey S, Pegram M, Wilson C, Grant G, Contag C, **Matin AC**. HER2-targeted extracellular vesicles delivery of therapeutic mRNA for enzyme prodrug therapy – possibility for targeting brain metastasis. NIH Trans agency blood brain interface Workshop, Exosome Therapeutics Session; June 2016
137. Masamitsu Kanada, John Ronald, Bryan D. Kim, Ramasamy Paulmurugan, Jessie Ge, Michael H. Bachmann, Jonathan W. Hardy, Sanjiv Sam Gambhir, **A.C. Matin**, Christopher H. Contag. Efficient delivery of minicircle DNA by extracellular vesicles as assessed by bioluminescence imaging. World Molecular Imaging Conference, 2016
138. Wang JH, Harada M, Delcayre A, Antes TJ, Gupta A, Kanada M, Green C, Jeffrey S, Pegram M, Contag C, **Matin AC**. HER2-targeted extracellular vesicles delivery of

therapeutic mRNA for enzyme prodrug therapy. Gordon Research Conference Extracellular Vesicles, Aug 21-26, 2016, Sunday River, Newry, ME

139. M. Kanada, B.D. Kim, J. Ronald, T.J. Ge, M.H. Bachmann, J.W. Hardy, S.S. Gambhir, **A.C. Matin**, R. Paulmurugan, C.H. Contag, Extracellular vesicle-mediated delivery of minicircle DNA encoding prodrug-converting enzymes for cancer therapy. The 2016 American Society for Exosomes and Microvesicles Annual Meeting, Oct. 20-24, 2016, Asilomar, CA, Abstract, 075
140. Harada, Masako, Jing-Hung Wang, Alexis Forterre, Alain Delcayre, Masamitsu Kanada, Christopher Contag, Stefanie Jeffrey, **AC Matin**. Targeted delivery of therapeutic microRNA to HER2-positive breast cancer. The 2016 American Society for Exosomes and Microvesicles Annual Meeting, Oct. 20-24, 2016, Asilomar, CA, Abstract, 068
141. Jing-Hung Wang, Masako Harada, Alexis Forterre, Alain Delcayre, Travis Antes, Archana Gupta, Masamitsu Kanada, Carol Green, Stefanie Jeffrey, Mark Pegram, Christopher Contag, **AC Matin**. HER2-targeted extracellular vesicles delivery of therapeutic mRNA for enzyme prodrug therapy. NIH Extracellular RNA Communication Consortium 7th Investigators' Meeting November 3rd and 4th, 2016 Bethesda North Marriott Hotel, Rockville, MD
142. Alexis Forterre, Jing-Hung Wang, Jingjing Zhao, Anastasia Khvorova, Stefanie Jeffrey, Alain Delcayre, and **AC Matin**. Enhancing the effectiveness of CNOB/HChrR6 regimen to treat HER2+ve breast cancer by improved gene delivery. NIH Extracellular RNA Communication Consortium 8th Investigators' Meeting April 6 & 7, 2017 Bethesda North Marriott Hotel, Rockville, MD, page 30
143. **Matin AC**, Wang JH, Keyhan M, Singh R, Benoit M, Parra MP, Padgen MR, Ricco AJ, Chin M, Friedericks CR, Chin TN, Cohen A, Henschke MB, Snyder TV, Lera MP, Ross SS, Mayberry CM, Choi S, Wu DT, Tan MX, Boone TD, Beasley CC, Piccini ME, Spremo SM. 2017 Payload hardware and experimental protocol development to enable future testing of the effect of space microgravity on the resistance to gentamicin of uropathogenic Escherichia coli and its σ^s -deficient mutant. Life Sci Space Res (Amst). 2017 Nov;15:1-10. doi: 10.1016/j.lssr.2017.05.001. Epub 2017 May 10.
144. Wang J-H, Forterre A, Zhao J, Frimannsson D, Delcayre A, Antes T, Efron B, Jeffrey S, Pegram M, **Matin A**. 2017. Anti-HER2 scFv-directed extracellular vesicle-mediated mRNA-based gene delivery inhibits growth of HER2-positive human breast tumor xenografts by prodrug activation. 9th exRNA Communication Meeting, November 6 & 7, 2017 Program, page 29
145. Alexis Forterre, Jing-Hung Wang, Anastasia Khvorova and **AC Matin**. 2017. Improving extracellular vesicles (EV)-mediated mRNA delivery specifically to HER2+ve cancer for effective CNOB/HChrR6 gene delivered ("EXO-DEPT") therapy 3rd World Congress and Expo on Oncology & Radiology, December 04-06, 2017 San Francisco, USA
146. Alexis Forterre, Jing-Hung Wang, Alain Delcayre, Travis Antes, Neil Aronin, Anastasia Khvorova, Stefanie Jeffrey and **A.C. Matin**. Improving extracellular vesicles-mediated mRNA delivery specifically to HER2+ve cancer for effective CNOB/hChrR6 gene-delivered (GDEPT) therapy ISEV2017 in Toronto, Canada May 18th-21st 2017

147. **Matin, AC.** Extracellular vesicle (EV)/prodrug-mediated specific treatment of HER2+ve breast cancer xenografts in mice. NIH Extracellular RNA Communication Consortium 10th Investigators' Meeting April 26-27, 2018, Bethesda North Marriott Hotel, Rockville, MD
148. Michael R. Padgen, Matthew P. Lera, Macarena P. Parra, Antonio J. Ricco, Matthew Chin, Tori N. Chinn, Aaron Cohen, Charlie R. Friedericks, Michael B. Henschke, Timothy V. Snyder, Stevan M. Spremo, and **AC Matin.** 2018. EcAMSat: Results from a small satellite examine the role the sigma factor σ^s plays in *E. coli*'s response in microgravity to the antibiotic gentamicin.
149. Alexis Forterre, Jing-Hung Wang; Reka Haraszti; Anastasia Khvorova and **AC Matin.** 2018. Optimizing loading and expression of HChrR6 mRNA in extracellular vesicles (EVs) for side effect-free prodrug-mediated treatment of HER2+ve breast cancer
150. **Matin, AC.** Role of bacterial antioxidant defense in their resistance to bactericidal antibiotics. Abstracts of 20th ISANH International Conference on Oxidative stress, redox homeostasis and antioxidants. June 25-26, 2018, Universite Pierre et Marie Curie, Paris France.
151. Jing-Hung Wang, Alexis V. Forterre, Jinjing Zhao, Daniel O. Frimannsson, Alain Delcayre, Travis J. Antes, Bradley Efron, Stefanie S. Jeffrey, Mark D. Pegram, and **A.C. Matin.** 2018. Anti-HER2 scFv-Directed Extracellular Vesicle-Mediated mRNA-Based Gene Delivery Inhibits Growth of HER2-Positive Human Breast Tumor Xenografts by Prodrug Activation. Gordon Research Seminar on Extracellular Vesicles meeting at Grand Summit Hotel, Sunday River (Newry, ME, US), Aug 18, 19 2018.
152. Alexis Forterre, Jing-Hung Wang Alain Delcayre, Kyuri Kim, Carol Green, Mark Pegram, Stefanie Jeffrey, **AC Matin.** EV-mediated *in vitro* transcribed (IVT) mRNA-based gene delivery for specific prodrug activation in the tumor treats breast cancer in mice with no offsite toxicity (OF11.02); Friday, April 25, 2019 (Symposium Session 11: EV Therapeutics.
153. Alexis V. Forterre, Jing-Hung Wang, Alain Delcayre, Kyuri Kim, Carol Green, Mark D. Pegram, Stefanie S. Jeffrey and **AC Matin.** EV-mediated *in vitro* transcribed (IVT) mRNA-based gene delivery for specific prodrug activation in the tumor treats breast cancer in mice with no offsite toxicity. French Society of Extracellular Vesicles, October 14th-15th Nantes. (Oral presentation by AF.)
154. **Matin, A.C. 9/22/2020.** Bacterial resistance to antimicrobials in microgravity/countermeasures. International Space Station R&D Conference; 4th talk in "Cell and Microbiology Results" session:
https://www.youtube.com/watch?v=kKAKgdZWYBo&list=PLlqpu1_OaN2LDuS4gP3evGrjesuT1pN0b&index=4
155. **Matin, A.C.** Directed gene therapy using mRNA. Cancer Science Virtual. October 2020

Editorial boards:

- 1980-2005: Editorial Board, Annual Review of Microbiology (6-times)
- 1988-1990: Editorial Board, Journal of Bacteriology
- 1998-present: Editorial Board, Journal of Microbiology
- 2008-present Editorial Board, Cancer Management and Research
- 2010-present Editorial Board, Journal of Molecular Imaging & Dynamics
- 2010-present Editor/Editorial Board, Journal of Bioprocessing & Biotechniques
- 2012-present Editor-in-Chief, Open Journal of Applied Sciences

Reviewer:

- Journal of Bacteriology
- Molecular Microbiology
- Journal of Biological Chemistry
- Proceedings of the National Academy of Sciences
- Cancer Gene Therapy
- PLoS Biology
- PloS One
- Journal of Microbiology
- Archives of Microbiology
- Microbiology
- Applied & Environmental Microbiology
- International Journal of Systematic Bacteriology
- Biochimica Biophysica Acta
- FEMS Microbiology Ecology
- FEMS Letters
- Bioremediation
- Bioengineering, Biotechnology
- Gene
- BioTechniques
- Bioremediation Journal
- Environmental Microbiology
- Acta Biotechnologica
- Environmental Science & Technology
- Cancer Research
- Clinical Cancer Research
- Nanoletters
- Free Radical Biology and Medicine
- Cancer Research
- Scientific Reports

Book Reviewer

- American Society for Microbiology Press
- Oxford University Press

Peer review Panels:

- Department of Energy Study Section, June 1996
- Department of Energy NABIR Study Section, May 1997
- NASA Biotechnology Study Section, January 2001
- NIH Study Section on membrane protein structure, July 2001
- Department of Energy Study Section on 'Genome to Life', May 2002
- NIH Environmental Institute Study Section, 2003
- NASA Study Section, July 2004
- NIH Special Emphasis Panel, November 2005
- Foundation for Research, Science and Technology, New Zealand, 2007 –
- NIH Drug Discovery and Molecular Pharmacology study section; chartered member: 2007 – 2012
- Canada Foundation for Innovation, 2008 –
- Georgia National Science Foundation, 2008 –
- Chair, NASA Panel on Research and Technology Development to Support Crew Health and Performance in Space Exploration Missions, 3/26/2014
- Stanford Microbiome panel
- NCI Special emphasis panel, NCI, ZCA1 SRB-8 (M1): 03/17/2016
- Cancer Research Wales
- Fondation pour la Recherche Médicale, 54 rue de Varenne – 75335 Paris cedex 07

Ad hoc Grant Reviewer:

- National Science Foundation
- Environmental Protection Agency
- Office of Naval Research
- Department of Energy
- Department of Defense
- Israel/American Foundation
- Natural Sciences and Engineering Research Council of Canada
- Association for International Cancer Research, UK.
- Czech Science Foundation.

Listed in:

- Encyclopedia.com
- Who's Who in the West
- International Who's Who of Professionals
- Asian/American Who's Who
- Who's Who in Medicine & Healthcare
- Who's Who in the World
- Who's Who in California
- Strathmore's Who's Who
- Who's Who in Science and Engineering
- Who's Who in America
- Who's Who in Frontiers of Science

- Manchester Who's Who
- Dictionary of International Biography – 28th Edition
- Outstanding People of the 20th Century
- International Directory of Distinguished People
- International Directory of Distinguished Leadership Hall of Fame
- International Directory of Distinguished Leadership
- Asia's Who's Who for Men and Women of Achievement
- Biography Fame International and other biographies
- Afro-Asian Who's Who
- World of Microbiology & Immunology

CONSULTANT

- Engenics Corporation, 1982 – 1985
- Monsanto Corporation, 1984 – 1986
- Clorox, 1992-1993
- Scientific Advisory Board, Institute of Molecular Medicine, New York, Kolkata: 2001-2003
- Technical Advisory Board, Chembiotek, Kolkata: 2001-2003
- Advisory Board, Chemgen Pharma International: 2004-2006
- Several one-time contractual projects

LEGAL EXPERIENCE

- Loeb & Loeb, 1982 – 1984
- Law firm of Swidler Berlin Shereff Friedman, LLP. 1999 – 2001

NUMBER OF PERSONNEL TRAINED

- >30 graduate students
- >70 postdoctoral fellows
- >60 undergraduate research students

COURSES TAUGHT (STANFORD)

- Microbial physiology and Ecology: 1975 – 1988
- Director: Comprehensive one-year course in Microbiology for Microbiology majors: 1989-91
- Freshman seminar: 1978
- Biological stress response: 1989 – 2006
- Topics in Microbiology: 1992 – 2003
- Topics in Cancer Biology: 2004 – present
- Pathogenesis of bacteria, viruses, and parasites 2000 – 2010

INVITED COURSES (OTHER INSTITUTIONS)

Course on *Bdellovibrio*, State University of Groningen, 1972

Course on Microbial Ecology, Laboratory of Microbiology, Gulbenkian Institute of Science. Oeiras, Portugal, March-May 1974.

Course on Microbial Interactions. Woods Hole Oceanographic Institution. Woods Hole, Massachusetts, July 1980.

Exobiology Program of National Aeronautics and Space Administration Course on Microbial Ecology. Moffett Field, California, August 1980.

Introductory Microbiology, University of California, Santa Cruz. Santa Cruz, California, 1981.

Exobiology Program of National Aeronautics and Space Administration Course on Microbial Ecology. Santa Clara, California, June-July 1982.

NASA Exobiology-Scripps Course on Microbial Sulfur Cycle. San Jose, California, Summer 1984.

Department of Microbiology & The East West Center, University of Hawaii: Molecular basis of the biological Stress response and its application to Bioremediation. Honolulu, Hawaii, April 1993.

Visiting Scholar and Keynote lecturer, International Symposium on molecular strategies for bioremediation (National Cheng Kung University). Sponsored by the National Science Council and the Ministry of Economic Affairs, Taiwan: September 11 – September 18, 2004 (Delivered three lectures on molecular bioremediation).

CONFERENCE PRESENTATIONS

Regulation of glucose metabolism in *Thiobacillus* species. American Society for Microbiology meeting, 1968.

The loss of NADH oxidase is not a property of obligate thiobacilli and (contrary to a recent report) does not account for their inability to grow on organic compounds. Round Table presentation. American Society for Microbiology, 1968.

Convener and speaker, American Society for Microbiology, Annual Meeting, “Continuous Culture in the Physiology and Ecology of Microorganisms”. New Orleans, Louisiana, May 1977.

Invited speaker, American Society for Microbiology, Annual Meeting, “Biology of Ureaplasma: Progress and Prospects”. Las Vegas, Nevada, May 1978.

Invited participant (speaker and contributor of a review), Dahlem Conference, “Strategies of Life in Extreme Environments”. Berlin, West Germany, November 1978.

Invited speaker, American Society for Microbiology, Annual Meeting, "Development and Ecological Interactions Among Prokaryotes". Los Angeles, California, May 1979.

Invited speaker, American Society for Microbiology, Annual Meeting, "Autotrophy". Miami Beach, Florida 1980.

Program Chairman and keynote speaker, West Coast Bacterial Physiologists Conference. Asilomar, California, 1981.

Invited contributor, American Society for Microbiology, Annual Meeting, "Bacterial Disinfection". Dallas, Texas, 1981.

Invited speaker, Round Table on Autotrophic Bacteria, XIII International Congress of Microbiology. Boston, Massachusetts, August 1982.

Invited speaker, Chemoautotrophy Colloquium. Columbus, Ohio, 1982.

Invited participant and speaker, Banbury Center, "Genetics of anaerobic bacteria". Cold Spring Harbor, New York, August 1982.

Invited speaker, IV International Symposium on C-1 Compounds, University of Minnesota. Minneapolis, Minnesota, September 1983.

Invited participant and speaker, Biogeochemistry Conference. Santa Fe, New Mexico, September 1983.

Gordon Conference on Proton and Membrane Reactions. Santa Barbara, California, February 1985

Invited symposium convener and speaker, ASM Annual Meeting, "Microbial Responses to Nutrient Deprivation". Washington, D.C., March 1986.

Convener of Roundtable on Bacterial Stress Proteins, XIV International Congress of Microbiology. Manchester, England, September 1986.

Invited co-convener and speaker, ASM conference on Protein Data Base. Atlanta, Georgia, March 1987.

Invited speaker, Conference on Membrane Transport and Receptors. Berkeley, California, June 1987.

Invited participant, Fourth International Conference on the Genetics and Biotechnology of Bacilli. San Diego, California, July 1987.

Convener and speaker of symposium on Microbial post-exponential phase, "Industrial Applications, Society for Industrial Microbiology Meeting". Baltimore, Maryland, August 1987.

- Invited speaker, Federation of European Microbiologists' Symposium on Homeostatic Mechanisms in Microorganisms. Warwick, England, September 1987.
- Gordon Conference on Stress Response, 1998
- Invited speaker, North Western Branch of American Society for Microbiology, "Carbon Starvation Genes of *Escherichia coli*: regulation and role in stress management". Bozeman, Montana, September 1988.
- Invited convener and speaker, American Society for Microbiology Meeting, "Physiological and Molecular Responses to Nutrient Deprivation in Non-differentiating Bacteria". New Orleans, Louisiana, May 1989.
- Invited participant and speaker, State University of Groningen, Council of the Royal Netherlands Academy of Arts and Sciences meeting on Adaptation of Microorganisms to Extreme Environments, "Keeping a neutral cytoplasm: the bioenergetics of obligate acidophiles". Groningen, Netherlands, June 1989.
- Invited speaker, Joint Meeting of the California Radiation Biology Symposium and the Northern California Cancer Center, "Bacterial Stress Proteins". Palo Alto, California, October 1989.
- Invited speaker, University of Goteborg Workshop on Nutrient limitation Regulons and prokaryotic development, "Starvation-induced differentiation into a resistant state in *E. coli*." Goteborg, Sweden, March 1990.
- Invited speaker, Radiation Research Society Workshop, "Non-thermal Effects of Heat-shock Proteins." New Orleans, Louisiana, April 1990.
- Invited speaker, Canadian Society of Microbiologists Annual Meeting, "The genetic Basis of Starvation and Other Stress Resistance in Non-differentiating Bacteria". Alberta, Canada, June 1990.
- Invited speaker, European Bioenergetics Conference, "Anion transport pathways and their bioenergetic implications in obligate acidophiles". The Netherlands, August 1990.
- Invited speaker, ASM conference on Multicellular Behavior of Bacteria in Nature, Industry and the Laboratory, Woods Hole Marine Biological Laboratory, "E. coli in hollow fiber bioreactors: expression of generalized resistance genes". Woods Hole, New York, October 1990.
- Invited speaker, Biochemical Engineering VII, "Molecular basis of the bacterial starvation response and its biotechnological implications". Santa Barbara, California, March 3-8, 1991.
- Invited speaker, Five Center Site Bioremediation Conference, Hazardous Substance Research Centers, Title of talk: "Use of starvation promoters in bioremediation". Gull Lake, Michigan, May 19-22, 1991.
- Invited convener and speaker, American Society for Microbiology Annual Meeting, Symposium on Biological Stress Response. Dallas, Texas, May 1991.

Invited speaker, Symposium on Role of Starved Bacteria in Food Processing and Spoilage. Society for Applied Bacteriology. Bristol, U.K., July 1991.

Invited keynote speaker, Theobald Smith Society–ASM Foundation lecturer, “Molecular basis of bacterial starvation response”. Newark, New Jersey, Sept. 1991.

Invited speaker, 26th Annual Meeting, NACMID–ASM Foundation lecturer, “Molecular basis of bacterial starvation response”. Galilee, Rhode Island, October 1991.

Invited speaker, American Society for Microbiology Annual Meeting, “Molecular basis of bacterial starvation response”. New Orleans, May 1992.

Invited speaker, North-West Branch of American Society for Microbiology–ASM Foundation lecturer, “Molecular basis of bacterial starvation response”. Parkfield, Wisconsin, November 1992.

Invited speaker and participant, Biotechnology Risk Assessment Symposium: USEPA, USDA, Environment Canada, “Starvation genes, promoters, and starvation survival fusion mutants of *Pseudomonas putida*.” College Park, Maryland, June 1994.

Invited speaker, DOE Meeting on Diversity in subsurface population of Cierro Negro. Salt Lake City, Utah, February 1995.

Invited speaker, Lawrence Livermore Conference on Yucca Mountain, “Starvation-specific bacterial physiology”. Lawrence Livermore National Laboratory, Livermore, California, March 1995.

Keynote speaker, 8th International Conference on Bacilli, Stanford University Meeting. Stanford, California, July 1995.

Invited speaker, Biotechnology Risk Assessment Symposium. Portland, Oregon, July 1995.

Invited speaker, Phage Meeting. Madison, Wisconsin, August 1997.

Invited speaker, European Biotechnology Conference, Budapest, Hungary, August 1997.

Keynote speaker, Joint Meeting of the Korean Biological Societies. Seoul, Korea, November 1997.

Invited speaker, Lawrence Livermore National Laboratory, “Unique correlates of microbial activity relevant to nuclear waste repositories.” Livermore, CA January 1998.

Invited speaker, Meeting on Microbiology and Infectious Disease, “Life in stationary phase.” Ma’ale Hachamisha, Israel, March 1998.

Invited speaker, Novartis Symposium: Mechanisms by which bacterial cells respond to pH, “pH homeostasis in acidophiles.” London, England, June 1998.

Invited speaker and scientific evaluator: Genetically Engineered Dwarf Cells. Oyster Stock-taking Meeting. Virginia Beach, VA, November 1998.

Invited speaker, Engineering of chromate reductase: ASM Sub-surface Meeting, Vail, Colorado, August 27, 1999.

Convener and speaker: American Society for Microbiology Symposium on "Molecular Approaches to Bioremediation, Los Angeles, CA., 22 May 2000.

Department of Energy Workshop on Field Research Site, September 21-22, 2000, Oakridge National Laboratory, Oakridge, Tennessee.

Department of Energy Workshop on Metal Microbe Interaction, October 11-12, 2000, Airlie Center, Virginia.

Molecular engineering of soluble bacterial chromate reductases. International conference on remediation of contaminated sediments – Battelle. Venice, Italy October 2001.

Department of Energy Meeting, Airlie Center Virginia: "Molecular biology of bacterial chromate reduction," March 2002.

Molecular engineering of soluble bacterial chromate reductases. International conference on remediation of contaminated sediments – Battelle. Venice, Italy October 2003.

Plenary speaker: International Symposium on "Challenges in drug discovery and development in the 21st century." Kolkata, India, March 24 – 27, 2001.

Molecular approaches to improve chromate bioremediation, Platform presentation, Twelfth Annual West Coast Conference on Contaminated Soils, Sediments and water, AEHS. San Diego CA. (3/18 – 3/21/02). (Talk presented by postdoc, C. Gonzalez.) 3/18/2002.

Molecular biology of bacterial chromate reduction, International Society for Environmental Biotechnology Symposium, Veracruz, Mexico, July 2002 (Talk presented by postdoc, D. Ackerley).

Invited Speaker, The bacterial stress response under microgravity conditions. In Symposium on Cells in microgravity: problems and prospects. Session 105/O, 102nd General meeting of the American Society for Microbiology, Utah, May 19-23, 2002.

Invited speaker, Biology of bacterial chromate reduction and its implications for bioremediation. Invited talk at JGI, DOE, Calif. Sept. 8, 2003.

Gordon Conference on Applied & Environmental Microbiology, 2003.

Invited Speaker, The altered molecular basis of bacterial stress response under microgravity conditions. Symposium on Low shear microbiology: global environmental regulatory signals affecting microbial gene expression, physiology and pathogenesis. 104th General meeting of the American Society for Microbiology, New Orleans, May 23 – 27, 2004; Symposium #228/O.

Invited Speaker, Biomolecular strategy to decrease chromate toxicity to remediating bacteria. Joint ACS 59th Rocky Mountain Regional Meeting, June 6 – 9, 2004, Logan, Utah.

Invited participants, DOE Workshop, "Cultivation technologies for meeting the challenges of systems microbiology and the genomics-GTL program," August 12-14, 2004, La Jolla, CA.

Speaker, Identification of targets of improvement and enzyme engineering to improve bacterial capacity for chromate bioremediation. International conference on remediation of contaminated sediments – Battelle. New Orleans, October 2005.

Invited participant: NASA P.I. meeting, Society for Gravitation and Space Biology, New York, N.Y., 9-12 November 2004.

Organizer, Chair, Speaker ("Molecular basis of increased resistance of planktonic and biofilm *Escherichia coli* cultures in microgravity"). 15th Humans in Space Symposium, Gratz, Austria, 22-26 May 2005.

Invited Speaker, Advanced Life Support System, American Society for Gravitational and Space Biology, Reno Nevada, November 1-4, 2005: "Effect of simulated microgravity on the resistance of bacterial planktonic and biofilm cells and its molecular basis.

Invited Speaker, DOE-ERSD PI Meeting, Warren Virginia, April 3-5, 2006, "Enzyme design for Cr(VI) and U(VI) reduction."

Invited Speaker, 11th World Congress on Advances in Oncology & 9th International Symposium on Molecular Medicine, 12-14 October 2006, Hersonissos, Crete, Greece: "Improved prodrug chemotherapy through directed enzyme evolution and discovery of a new prodrug.

Invited Speaker, American Chemical Society, Chicago, Illinois: "Enzyme design for Cr(VI) and U(VI) reduction." 2007 (Highlighted in Chemical & Engineering News, 2007, 85: 40).

Invited Speaker, *Remediation Technologies for Chromium*. Symposium at 233rd American Chemical Society National Meeting, March 25-29, 2007, Chicago, ILL.

Invited Speaker, Physician's Round Table, January 27-30, 2011, Virginia Beach, VA, USA: "Bacterial biofilms and progress towards combating them."

Invited Speaker, Delivery via exosomes of improved ChrR enzyme mRNA specifically to Her2+ve tumors to activate a new visualizable prodrug, CNOB. Translational Medicine Program at Stanford. November 2013.

Chair: Development of Extracellular Vesicle Therapeutics, NIH Extracellular RNA Communication Consortium, 2nd Investigators' Meeting, Monday May 19th – Tuesday May 20th, 2014.

Invited Speaker, NASA AMES at Moffett Field: Molecular findings to increase gentamicin sensitivity of UPEC. June 5, 2014.

Invited Speaker, NASA AMES at Moffett Field: Development of EcAMSat platform for determining the molecular basis of enhanced gentamicin resistance of uropathogenic *E. coli* under microgravity conditions. Several talks on this/similar topic between 2011 – 2016.

Invited speaker, Extracellular vesicle types/definitions. NIH Extracellular RNA Communication Consortium 6th Investigators' Meeting May 2015, Bethesda North Marriott Hotel, Rockville, MD.

Invited Speaker, Exosome cargo function & cargo sorting. NIH Extracellular RNA Communication Consortium 7th Investigators' Meeting November 3rd and 4th, 2016 Bethesda North Marriott Hotel, Rockville, MD.

Invited Speaker, HER2-targeted Extracellular Vesicle Delivery of Therapeutic mRNA for Enzyme Prodrug Therapy. NIH Extracellular RNA Communication Consortium 7th Investigators' Meeting November 3rd and 4th, 2016 Bethesda North Marriott Hotel, Rockville, MD.

Invited Speaker – Video presentation: EcAMSat: Effect of Spaceflight on Antibiotic Resistance of a Pathogenic Bacterium and its Genetic Basis. ISS Science Symposium, July 11, 2017

Invited speaker, Select Biosciences Extracellular Vesicles 2017 Conference, 26-28 September 2017, Cambridge, UK: “EV-delivered therapeutic mRNA specifically to Her2+ve breast cancer for prodrug therapy”.

Invited Speaker, Readiness of the biological component for the planned space experiment aboard a nanosatellite. October 17, 2017, NASA, Moffett Field.

Invited Speaker, Workshop on Vesicle Isolation & Function: Translating vesicle biology to clinical therapy: 9th EERC meeting, November 5th, 2017 at the Hilton Rockville Hotel: “Making EVs that deliver functionally competent mRNA to the intended target cells/tumors”.

Invited Speaker, Session IV: Therapeutic Uses of exRNA and Extracellular Vesicles, 9th EERC meeting, November 5th, 2017 at the Hilton Rockville Hotel: “Anti-HER2 scFv-directed extracellular vesicle-mediated mRNA-based gene delivery arrests growth of HER2-positive human breast tumor xenografts by prodrug activation” (Talk presented on Nov. 6.)

Invited speaker (above topic): NIH Extracellular RNA Communication Consortium 10th Investigators' Meeting April 26-27, 2018, Bethesda North Marriott Hotel, Rockville, MD

Invited speaker. Role of bacterial antioxidant defense in their resistance to bactericidal antibiotics. 20th ISANH International Conference on Oxidative stress, redox homeostasis and antioxidants. June 25-26, 2018, Universite Pierre et Marie Curie, Paris France.

Invited speaker. Targeted prodrug treatment of HER2+ve human breast cancer. 1st Annual Bay Area Exosome Research Festival - July 13, 2018, Byers Auditorium, Genentech Hall UCSF

Invited talk (presented by post doc, Alexis Forterre). HER2 scFv-Directed Extracellular Vesicle-Mediated mRNA-Based Gene Delivery Inhibits Growth of HER2-Positive Human Breast Tumor Xenografts by Prodrug Activation. Gordon Research Seminar on Extracellular Vesicles meeting at Grand Summit Hotel, Sunday River (Newry, ME, US), Aug 18, 19 2018.

Invited speaker. Exosome-mediated systemic gene delivery for treatment of cancer. International Society for Extracellular Vesicles meeting, Kyoto Japan, Friday, April 25, 2019 (Symposium Session 11: EV Therapeutics).

Invited video presentation, LabRoots: Extracellular vesicle-mediated mRNA-based gene-delivery for targeted and safe treatment of HER2-positive breast cancer in mice by prodrugs: A new GDEPT approach. Can be accessed at:
<https://www.youtube.com/watch?v=OM6SiRrfk1A>

Invited speaker. Earth and space research interface/bacterial antibiotic resistance/*EcAMSat*. Space Life and Biomedical Science Symposium. March 4th, 2020 Harwell Campus, Didcot, Oxfordshire.

Invited speaker. Bacterial resistance to antimicrobials in microgravity/countermeasures. International Space Station R&D Conference, 9/22/2020. 4th talk in “Cell and Microbiology Results” session:
https://www.youtube.com/watch?v=kKAkgdZWYBo&list=PLlqpu1_OaN2LDuS4gP3evGrjesuT1pN0b&index=4

INVITED UNIVERSITY/INDUSTRY SEMINARS

- Department of Microbiology, University of California, Davis. Davis, California, 1969.
- Department of Bacteriology, University of Wisconsin. Madison, Wisconsin, 1970.
- Department of Microbiology, University of Amsterdam. Amsterdam, The Netherlands, 1972.
- Max Planck Institute. Berlin, West Germany, 1973.
- University of Bonn. Bonn, West Germany, 1973.
- University of Heidelberg. Heidelberg, West Germany, 1973.
- University of Kiel. Kiel, West Germany, 1973.
- Department of Bacteriology, University of California, Los Angeles, 1974
- Department of Bacteriology, University of California, Los Angeles, 1976
- University of Amsterdam. Amsterdam, The Netherlands, 1979.
- Scripps Oceanic Institute, 1982
- Department of Biology, Rensselaer Polytechnic Institute. Troy, New York, November 1984.

- Department of Biology, Yale University. New Haven, Connecticut, November 1984.
- Monsanto Chemical Co. St. Louis, Missouri, 1985.
- Department of Microbiology, University of Montana, "Genetic basis of starvation survival in *E. coli*". Bozeman, Montana, June 1987.
- Genentech, "Biotechnological applications of *E. coli* stress response". San Francisco, California, October 1987.
- Department of Bacteriology, University of Wisconsin, "Starvation-gene expression in *E. coli*". Madison, Wisconsin, July 1988.
- Presentation to the Dean's Panel, School of Engineering, Stanford University. "Biotechnological applications of *E. coli* stress response". Stanford, California, February 1989.
- Linus Pauling Institute, "Starvation-induced differentiation in *E. coli*". Palo Alto, California, April 1989.
- Office of Competitive Technology, California Department of Commerce, "Biotechnological exploitation of gene expression systems unique to metabolically inert cells". April 1989.
- Department of Physical Chemistry, Technical University of Norway, "Biotechnological exploitation of gene expression systems unique to metabolically inert cells". Trondheim, Norway, June 1989.
- Genentech, "Biotechnological exploitation of Gene expression systems unique to metabolically inert *E. coli* cells". San Francisco, California, December 1989.
- Pathogenic Affinity Group, Research Institute of Scripps Clinic. San Diego, California, December 1990.
- Clorox Corporation. Bacterial biofilms. Pleasanton, California, May 1992.
- Department of Molecular and Cell Biology, Penn State University. March 1992.
- Department of Bacteriology, University of Wisconsin. Madison, Wisconsin, November 1992.
- Engineering Foundation International Meeting on Biotechnology. February 1993.
- University of Wisconsin. Parkfield, Wisconsin, April 1993.
- Astar Hassle Pharmaceutical Company, "Therapeutic implications of a pH gradient in *Helicobacterium pylori*." Molndal, Sweden, September 1993.
- University of British Columbia. Vancouver, Canada, November 1993.

- Genecore. South San Francisco, California, October 1995.
- Institute for Microbiology, University of Gottingen. Gottingen, Germany, November 1995.
- Konstanz University. Konstanz, Germany, November 1995.
- National Research Center for Biotechnology. Braunschweig, Germany, November 1995.
- Department of Biology, University of California, San Diego: February 1996.
- Center for Environmental Biotechnology, Lawrence Berkeley National Laboratory, Berkeley, CA.: April 1996.
- University of California, San Diego, June 1996.
- ETEH, Zurich, Switzerland, October 1996.
- University of Madrid, Center for Biotechnology, Madrid, Spain, October 1996.
- University of Barcelona, Department of Microbiology and Pharmacy, Barcelona, Spain October 1996.
- Ernst Moritz University, Greifswald, Germany: "A G-protein mediates *Pseudomonas* stress resistance and correct flagellar placement." 21 March 2000.
- Biozentrum, Division of Molecular Biology, University of Basel, Switzerland: "Molecular basis of stress sensing by the *P. putida* G-protein, and its role in polar flagellar placement." 13 June 2000
- Department of Microbiology, University of Bath, England, October 23, 2000. (Seminar topic: Role and regulation of the general stress response.)
- Department of Microbiology and Molecular Genetics, University of California, Los Angeles, February 9, 2000. (Seminar topic: Role and regulation of the general stress response.)
- Faculte de Medicine, University of Paris, April 26, 2001 (Role and regulation of the general stress response.)
- Biological Faculty, University of Milan, Italy, October 2001
- Los Altos Rotary Club: "New Biology: impact on disease and pollution control and space exploration." 5/15/01
- Swiss Federal Institute for Environmental Science and Technology, Switzerland, October 8, 2002
- Keynote speaker, "Molecular approaches to improve bacterial bioremediation capacity with special reference to chromate bioremediation", International Symposium of Environmental Biotechnologies on Bioenergy and Bioremediation. National Cheng Kung

University, Tainan, Taiwan, September 2004 (Two additional talks at affiliated Institutes on other aspects of molecular bioremediation)

- Effect of microgravity on bacteria and human immune response: Kennedy Space Center, Florida, March 2005.
- International Cancer Congress, Crete, Greece: 'A new prodrug/enzyme cancer treatment regimen', 2006.
- "Enzyme design for Cr(VI) and U(VI) reduction", NABIR meeting at Airlie Center, April 2006.
- Brookhaven National Laboratory, May 2007: "ChrR, an enzyme for all seasons – from bioremediation to cancer chemotherapy"
- Caradache, Aix en Provence, France, September 2007: "ChrR, an enzyme for all seasons – from bioremediation to cancer chemotherapy"
- Above lecture at Stanford Bug Club – January 2008.
- ICMIC Meeting, Stanford University: "Nanoparticle-mediated delivery of a novel prodrug regimen to prostate cancer – January 2011
- Pacific Northwest National Laboratory, July 2011: "Bacterial ChrR, an Enzyme for all Seasons: from Combating Oxidative Stress to Application in Bioremediation and Cancer Chemotherapy".

UNIVERSITY SERVICE

- Revised the Bulletin description of Departmental Undergraduate Major, 1977
- Member, Stanford Recombinant DNA Panel, 1979-1982
- Chairman, Stanford Recombinant DNA Panel, 1982
- Member, Department Admissions Committee, 1975-1988; Chair of the Committee, 85 - 88
- Member, Steering Committee of Departmental Training Grant 1988-2000
- Faculty Preceptor, Training Grant in Cellular and Molecular Biology 1980-82; 1985-present
- Chairman, Committee to reorganize Introductory Microbiology course series, 1989-91
- Member, Departmental Curriculum Committee, 1989-2000
- Member, Departmental Search Committee for a position in Microbiology, 1990
- Coordinator (for several years), Internal Department seminar series
- Coordinator, Microbiology and Immunology External Speaker Seminar series, 1976-78; 1984-85
- Departmental Representative to the Committee on Pauling lectureship, 1985
- Departmental senator 1977-80; Alternate senator, 2001 - 2005
- Departmental Senator, 2006 – 2011
- Member, Steering Committee, Medical School Senate, 2007-2011
- Chair, Medical School Post-doctoral Student Task Force, 2007-2011
- Advisor, Departmental Undergraduate Major/Program, 1990-1995
- Member, Search Committee, position in eukaryotic microbiology, Dept. of Microbiology & Immunology

- Freshman adviser, 1975 – 2009 (in various years)

FUNDING SOURCES FOR SPONSORED RESEARCH

(Many of the grants were multi-investigator on which I served as PI; institutions involved: Stanford; UC, Berkeley; Univ. of Michigan; Univ. of Saskatchewan, Canada; Caradasch, France)

- National Science Foundation
- National Institutes of Health
- National Cancer Institute
- Department of Energy
- Environmental Protection Agency
- Center for Biotechnology Research
- American Cancer Society
- Keck Foundation
- National Aeronautics and Space Administration
- State of California Office of Competitive Technology
- Oak Ridge National Laboratory
- Department of Agriculture
- Western Region Hazardous Substances Research
- NATO
- Alberta Research Council
- Stanford Institute for Energy Research
- Genentech
- Veteran's Administration
- Marie Curie Foundation
- California Institute for Regenerative Medicine
- Department of Defense
- National Center for Advancing Translational Research
- Parke Davis

PIONEERING RESEARCH CONTRIBUTIONS

- Biology and physiology of mixotrophy
- Biophysical basis of acidophilism
- Starvation responses at the cellular level
- Molecular basis of starvation response and starvation-mediated general resistance
- Use of starvation promoters in environmental biotechnology
- Bacterial multidrug resistance
- Bacterial biofilm resistance
- Novel mechanisms of bacterial antibiotic resistance
- Role of G proteins in starvation and motility
- Molecular strategies for heavy metal and radionuclide remediation
- Discovery of an imageable cancer prodrug
- Discovery of a new enzyme for prodrug cancer chemotherapy and its improvement
- Biomolecular imaging
- Novel drug delivery methods
- Development of heritable contrast agent for molecular resonance imaging
- Use of extracellular vesicles (exosomes) for specific gene and drug delivery to tumors

- Use of exogenous mRNA for gene delivery by extracellular vesicles
- Pioneering work for directed gene delivery upon systemic administration to treat cancer without side effects