

July 2010

CURRICULUM VITAE

NORMAN R. PACE

Department of Molecular, Cellular and Developmental Biology
University of Colorado
Boulder, CO 80309-0347
Telephone 303-735-1864, Fax 303-492-7744
nrpace@colorado.edu

Education

1964	B.A. (Honors), Indiana University, Bloomington, Indiana
1967	Ph.D., University of Illinois, Urbana, Illinois
1967-69	Postdoctoral Fellow, University of Illinois, Urbana, Illinois

Academic Positions

1969-74	Assistant Professor of Biophysics and Genetics, University of Colorado Medical Center
1969-74	National Jewish Hospital and Research Center, Division of Molecular and Cellular Biology
1975-82	Associate Professor of Biophysics and Genetics, University of Colorado Medical Center
1982-84	Professor of Biochemistry, Biophysics, and Genetics, University of Colorado Medical Center
1984-92	Professor of Biology, Indiana University
1992-94	Distinguished Professor of Biology, Indiana University
1994-96	Distinguished Professor of Biology and Chemistry, Indiana University
1996-99	Professor of Plant and Microbial Biology, and Molecular and Cell Biology, UC Berkeley
1999-08	Professor of Molecular, Cellular and Developmental Biology, University of Colorado, Boulder
2008-	Distinguished Professor of MCD Biology, University of Colorado, Boulder

Professional Societies and Some Activities

National Academy of Sciences.
American Society for Microbiology.
American Society of Biological Chemists; Editorial Board of "The Journal of Biological Chemistry," 1980-84.
National Speleological Society, Fellow; Bicking Award, 1987.
NRC/Space Science Board Committee on Planetary Biology and Chemical Evolution, 1985- 1989.
Space Science Board Mars Rover/Sample Return Advisory Committee, 1987-88.
Office of Technology Assessment Human Genome Mapping Review Board, 1987-88.
Co-Chairman, 1988 Gordon Conference on Nucleic Acids.
Co-Organizer, 1989 Cold Spring Harbor Meeting on RNA Processing.
Canadian Institute for Advanced Research, Program Associate, 1993-
NRC/Space Studies Board Committee on Planetary and Lunar Exploration, 1989-1995.
Co-Organizer RNA '96, 1996 RNA Society Meeting
Editorial Board, "RNA," the Journal of The RNA Society, 1995 -
Board of Scientific Counselors, Natl. Center for Biotechnology Information, Natl. Library of Medicine, 1994-
Editorial Board, "Environmental Microbiology", 1998 -
Scientific Advisory Council, Paratuberculosis Awareness and Research Association (PARA), 2000-
Board of Directors, Monterey Bay Aquarium Research Institute (MBARI), 2000-
NRC/Space Studies Board Committee on Origin and Evolution of Life, 1999-

Some Recognition

1989, Fellow, American Association for the Advancement of Science.
1991, Member, National Academy of Sciences.
1991, Fellow, American Academy of Arts and Sciences.
1995, Fellow American Academy of Microbiology.

1996, Procter and Gamble Award in Applied and Environmental Microbiology (Am. Soc. for Microbiol.).
1997, D. Sc. (Honorary), University of British Columbia.
2001, Selman A. Waksman Award for Excellence in Microbiology (National Academy of Sciences).
2001, Fellow, John D. and Catherine T. MacArthur Foundation.
2007, Abbott-American Society for Microbiology Lifetime Achievement Award.
2008, RNA Society Lifetime Achievement Award.
2008, International Society for Microbial Ecology Tiedje-ISME Lifetime Achievement Award.

Current Research Support

1984-2012 Principal Investigator, USPHS Grant GM 34527; MERIT Award, 1993
2006-2010 Principal Investigator, NIOSH Grant R01 OH009064
2000-2008 Investigator, NASA Astrobiology Institute

Current Research Activities

Research interests revolve about the synthesis, structure and function of RNA; and the application of molecular biological tools to problems in environmental microbial biology.

One effort of the laboratory is the study of Ribonuclease P, an RNA processing enzyme responsible for removing the 5' termini of tRNA precursors during their maturation. This is a particularly interesting enzyme because the catalytic element is itself RNA; RNase P is a ribozyme. Studies underway include analyses of the structure of the RNase P RNA, the nature of its interaction with tRNA precursors and other substrates, and the mechanism of the RNA-catalyzed reaction.

A second emphasis is on developing methods for analyzing phylogenetic and quantitative aspects of natural microbial populations without the necessity for laboratory cultivation. The methods rely on cloning and sequencing ribosomal RNA (rRNA) genes for phylogenetic analyses, and the use of rRNA-based hybridization probes for various studies of microbial ecosystems. Investigations are broadly directed, for instance toward high-temperature environments, unusual symbioses, environmental bioremediation, selected human diseases and the indoor environment all around us.

Publications:

1. Fraser, D., C.J. Pfau, and N.R. Pace. (1960). Identification of the protoplast-infecting and cell-infecting agent derived from T2 bacteriophage. *Proc. Indiana Acad. Sci.* 69:101-105.
2. Pace, N.R. and S. Spiegelman. (1966). The synthesis of infectious RNA with a replicase purified according to its size and density. *Proc. Natl. Acad. Sci. USA* 55:1608-1615.
3. Pace, N.R. and S. Spiegelman. (1966). The *in vitro* synthesis of an infectious mutant RNA with a normal RNA replicase. *Science* 153:64-67.
4. Mills, D.R., N.R. Pace, and S. Spiegelman. (1966). The *in vitro* synthesis of a non-infectious complex containing biologically active viral RNA. *Proc. Natl. Acad. Sci. USA* 56:1778-1785.
5. Spiegelman, S., I. Haruna, and N.R. Pace. (1966). Properties of a purified RNA replicase. *Biochim. et Biophys. Acta. Lunteren Symposium. The Netherlands*, pp. 3-28.
6. Spiegelman, S., I. Haruna, and N.R. Pace. (1966). Studies on the synthesis of a viral nucleic acid with a purified enzyme. *Second International Symposium for Cellular Chemistry*.
7. Bishop, D.H.L., J.R. Claybrook, N.R. Pace, and S. Spiegelman. (1967). An analysis by gel electrophoresis of Q β RNA complexes formed during the latent period of an *in vitro* synthesis. *Proc. Natl. Acad. Sci. USA* 57:1474-1481.
8. Pace, N.R., D.H.L. Bishop, and S. Spiegelman. (1967). Examination of the Q β replicase reaction by sucrose-gradient and gel electrophoresis. *J. Virol.* 1:771-778.

9. Pace, N.R., D.H.L. Bishop, and B. Spiegelman. (1967). The kinetics of product appearance and template involvement in their *in vitro* replication of viral RNA. Proc. Natl. Acad. Sci. USA 58:711-718.
10. Pace, N.R. (1967). *In vitro* studies of viral RNA replication. Ph.D. Thesis, The University of Illinois. Urbana. 139 pp.
11. Spiegelman, S., I. Haruna, N.R. Pace, D.R. Mills, D.H.L. Bishop, J.R. Claybrook, and R. Peterson. (1967). Studies in the replication of viral RNA. J. Cell Physiol. Suppl. 70:35-64.
12. Pace, N.R., I. Haruna, and S. Spiegelman. (1968). The preparation of an RNA replicase capable of synthesizing biologically active viral RNA. In "Methods in Enzymology," vol. 12, pt. B, Colowick and Kaplan (eds.), pp. 540-555.
13. Spiegelman, S., I. Haruna, N.R. Pace, D.R. Mills, and D.H.L. Bishop. (1968). The development and the use of an *in vitro* system for RNA replication. In "The Biochemistry of Virus Replication," Univesitets-forloget. Oslo, pp. 1-35.
14. Bishop, D.H.L., N.R. Pace, and S. Spiegelman. (1967). The mechanism of replication: a novel polarity reversal in the *in vitro* synthesis of Q β RNA and its complement. Proc. Natl. Acad. Sci. USA 58:1790-1797.
15. Pace, N.R., D.H.L. Bishop, and S. Spiegelman. (1968). The immediate precursor of viral RNA in the Q β replicase reaction. Proc. Natl. Acad. Sci. USA 59:139-144.
16. Pace, N.R., D.H.L. Bishop, D.R. Mills, M. Taylor, and S. Spiegelman. (1968). *In vitro* replication of viral RNA. Arch. Roum. Path. Exp. Microbiol. 27:519-540.
17. Spiegelman, S., N.R. Pace, D.R. Mills, R. Levisohn, T.S. Eikhom, M.M. Taylor, R.L. Peterson, and D.H.L. Bishop. (1968). The mechanism of RNA replication. Cold Spring Harbor Symp. Quant. Biol. 33:101-124.
18. Spiegelman, S., N.R. Pace, D.R. Mills, R. Levisohn, T.S. Eikhom, M.M. Taylor, R.L. Peterson, and D.H.L. Bishop. (1969). Chemical and mutational studies of a replicating RNA molecule. Proc. 12th Internatl. Congr. Genetics 3:127-154.
19. Pace, B., R.L. Peterson, and N.R. Pace. (1970). Formation of all stable RNA species in *Escherichia coli* by post transcriptional modification. Proc. Natl. Acad. Sci. USA 65:1097-1104.
20. Doolittle, W.F. and N.R. Pace. (1970). The synthesis of 5S ribosomal RNA in *E. coli* treated with rifampicin. Nature 228:128-129.
21. Pace, B. and N.R. Pace. (1971). Gene dosage for 5S ribosomal RNA in *E. coli* and *B. megaterium*. J. Bacteriol. 105:142-149.
22. Sogin, M., B. Pace, N.R. Pace, and C.R. Woese. (1971). The primary structural relationship of P16 and m16 ribosomal RNA in *E. coli*. Nature New Biology 232:48-49.
23. Doolittle, W.R. and N.R. Pace. (1971). Transcriptional organization of the ribosomal RNA cistrons in *Escherichia coli*. Proc. Natl. Acad. Sci. USA 68:1786-1790.
24. Peterson, R.L., C.W. Radcliffe, and N.R. Pace. (1971). RNA synthesis in *Escherichia coli* treated with toluene. J. Bacteriol. 107:585-588.
25. Averner, M. and N.R. Pace. (1972). The nucleotide sequence of marsupial 5S ribosomal RNA. J. Biol. Chem. 247:449-4493.

26. Pace, N.R., M.L. Pato, J. McKibbin, and C.W. Radcliffe. (1973). Precursors of 5S ribosomal RNA in *Bacillus subtilis*. *J. Mol. Biol.* 75:619-631.
27. Erikson, E., R.L. Erikson, B. Henry, and N.R. Pace (1973). Comparison of oligonucleotides produced by RNase T1 digestion of 7S RNA from avian and murine oncornaviruses and from uninfected cells. *Virology* 53:40-46.
28. Pace, N.R. (1973). The structure and synthesis of the ribosomal RNA of prokaryotes. *Bacteriol. Rev.* 37:562-603.
29. Sogin, M.L., C.R. Woese, B. Pace, and N.R. Pace. (1973). The relationship between precursor and mature forms of the 23S ribosomal RNA. *J. Mol. Evol.* 2:167-174.
30. Pace, N.R., T.A. Walker, B. Pace, and R.L. Erikson. (1974). The nucleotide sequence of chicken 5S ribosomal RNA. *J. Mol. Evol.* 3:151-159.
31. Pace, N.R. and M.L. Sogin. (1974). *In vitro* maturation of precursors of 5S ribosomal RNA from *Bacillus subtilis*. In "The 1974 Brookhaven Symposium in Biology," Vol. 26, Dunn and Studier (eds.), pp. 224-239.
32. Walker, T.A., N.R. Pace, R.L. Erikson, E. Erikson, and F. Behr. (1974). The 7S RNA common to oncornaviruses and normal cells is associated with polyribosomes. *Proc. Natl. Acad. Sci. USA* 71:3390-3394.
33. Sogin, M.L. and N.R. Pace. (1974). *In vitro* maturation of precursors of 5S ribosomal RNA from *Bacillus subtilis*. *Nature* 252:5987-6000.
34. Pribula, C.D., G.E. Fox, C.R. Woese, M. Sogin, and N.R. Pace. (1974). Nucleotide sequence of *Bacillus megaterium* 5S RNA. *FEBS Lett.* 44:322-323.
35. Walker, T.A., J. Betz, J. Olah, and N.R. Pace. (1975). The nucleotide sequence of dolphin and bovine 5S ribosomal RNA. *FEBS Lett.* 54:241-244.
36. Marotta, C.A., F. Varricchio, I. Smith, S.M. Wiessman, M.L. Sogin, and N.R. Pace. (1976). The primary structure of *Bacillus subtilis* and *Bacillus stearothermophilus* 5 S ribonucleic acids. *J. Biol. Chem.* 251:3122-3127.
37. Sogin, M.L., N.R. Pace, M. Rosenberg, and S.M. Weissman. (1976). The nucleotide sequence of a 5S ribosomal RNA precursor from *Bacillus subtilis*. *J. Biol. Chem.* 251:3480-3488.
38. Sogin, M.L., B. Pace, and N.R. Pace. (1977). Partial purification and properties of a ribosomal RNA maturation endonuclease from *Bacillus subtilis*. *J. Biol. Chem.* 252:1350-1357.
39. Walker, T.A. and N.R. Pace. (1977). The transcriptional organization of the 5.8S ribosomal RNA cistron in *Xenopus laevis*. *Nucleic Acids. Res.* 4:595-601.
40. Schroeder, E., M.L. Sogin, and N.R. Pace. (1977). The mode of degradation of precursor-specific RNA fragments by *Bacillus subtilis*. *J. Bacteriol.* 130:1000-1009.
41. Meyhack, B., B. Pace, and N.R. Pace. (1977). Involvement of precursor-specific segments in the *in vitro* maturation of *Bacillus subtilis* precursor 5S ribosomal RNA. *Biochemistry* 16:5009-5015.
42. Pace, N.R., E. Schroeder, and T.A. Walker. (1977). The structure of the 5.8S RNA component of the 5.8S-28S ribosomal RNA junction complex. *Biochemistry* 15:5321-5328.
43. Meyhack, B., B. Pace, O. Uhlenbeck, and N.R. Pace. (1978). Use of T4 RNA ligase to construct model substrates for a ribosomal RNA maturation endonuclease. *Proc. Natl. Acad. Sci. USA* 75:3045-3049.
44. Meyhack, B. and N.R. Pace. (1978). Involvement of the mature domain in the *in vitro* maturation of *Bacillus subtilis* precursors 5S ribosomal RNA. *Biochemistry* 17:5804-5810.

45. Ludi, G.A. and N.R. Pace. (1979). The use of rifampicin to evaluate tRNA gene transcriptional organization in *Escherichia coli*. *Nucleic Acids Res.* 6:1269-1286.
46. Stahl, D.A., T.A. Walker, B. Meyhack, and N.R. Pace. (1979). Precursor-specific nucleotide sequences can govern RNA folding. *Cell* 18:1133-1143.
47. Pace, N.R., B. Meyhack, B. Pace, and M.L. Sogin. (1980). The interaction of RNase M5 with a 5S ribosomal RNA precursor. In "tRNA: Biological Aspects," J. Abelson, P. Schimmel, and D. Soll (eds.), Cold Spring Harbor Laboratory, Cold Spring Harbor, N.Y., pp. 155-171.
48. Stahl, D.A., B. Meyhack, and N.R. Pace. (1980). Recognition of local nucleotide conformation in contrast to sequence by a ribosomal RNA-processing endonuclease. *Proc. Natl. Acad. Sci. USA* 77:5644-5648.
49. Pace, B. and N.R. Pace. (1980). The chromatography of RNA and oligoribonucleotides in boronate-substituted agarose and polyacrylamide. *Anal. Biochem.* 107:128-135.
50. Gardiner, K. and N.R. Pace. (1980). RNase P of *Bacillus subtilis* has an RNA component. *J. Biol. Chem.* 255:7507-7509.
51. Stahl, D.A., K.R. Luehrsen, C.R. Woese, and N.R. Pace. (1981). An unusual 5S RNA, from *Sulfolobus acidocaldarius*, and its implications for a general 5S rRNA structure. *Nucleic Acids Res.* 9:6129-6137.
52. Pace, B., E. Matthews, K. Johnson, C. Cantor, and N.R. Pace. (1981). Interaction between conserved 5S rRNA and tRNA complementary sequences is not required for protein synthesis. *Proc. Natl. Acad. Sci. USA* 79:36-40.
53. Walker, T.A., K. Johnson, G.A. Olsen, M. Peters, and N.R. Pace. (1982). Enzymatic and chemical structure mapping of mouse 28S ribosomal RNA contacts in 5.8S ribosomal RNA. *Biochemistry* 21:2320-2329.
54. Peters, M., T.A. Walker, and N.R. Pace. (1982). Independent binding sites in mouse 5.8S ribosomal RNA for 28S ribosomal RNA. *Biochemistry* 21:2330-2335.
55. Pace, N.R., K. Gardiner, B. Meyhack, B. Pace, M.L. Sogin, and D.A. Stahl. (1982). RNA processing in *Bacillus subtilis*. In "Microbiology," D. Schlessinger (ed.), pp. 32-40.
56. Walker, T.A., Y. Endo, W.H. Wheat, I.G. Wool, and N.R. Pace. (1983). Location of 5.8S rRNA contact sites in 28S rRNA, and the effect of a-sarcin on the association of 5.8S rRNA with 28S rRNA. *J. Biol. Chem.* 258:333-338.
57. Pace, N.R. (1983). Protein-polynucleotide recognition and the RNA-processing nucleases in prokaryotes. In "Processing of RNA," D. Apirion (ed.), CRC Press, pp. 1-34.
58. Walker, T.A. and N.R. Pace. (1983). 5.8S ribosomal RNA. *Cell* 33:320-322.
59. Guerrier-Takada, C., K. Gardiner, T. Marsh, N.R. Pace, and S. Altman. (1983). The RNA moiety of ribonuclease P is the catalytic subunit of the enzyme. *Cell* 35:849-857.
60. Zagorska, L., J. Van Duin, H.F. Noller, B. Pace, K.D. Johnson, and N.R. Pace. (1984). The conserved 5S rRNA complement to tRNA is not required for translation of natural mRNA. *J. Biol. Chem.* 259:2798-2802.
61. Stahl, D.A., D.J. Lane, G.J. Olsen, and N.R. Pace. (1984). The analysis of hydrothermal vent-associated symbionts by ribosomal RNA sequences. *Science* 224:409-411.
62. Stahl, D.A., B. Pace, T. Marsh, and N.R. Pace. (1984). The ribonucleoprotein substrate for a ribosomal RNA-processing nuclease. *J. Biol. Chem.* 259:11448-11453.

63. Pace, B., D.A. Stahl, and N.R. Pace. (1984). The catalytic element of a ribosomal RNA-processing complex. *J. Biol. Chem.* 259:11454-11458.
64. Lane, D.J., D.A. Stahl, G.J. Olsen, and N.R. Pace. (1985). Analysis of hydrothermal vent-associated symbionts by ribosomal RNA sequences. *Proc. Biol. Soc. Wash.* 6:389-400.
65. Pace, N.R., D.A. Stahl, D.J. Lane, and G.J. Olsen. (1985). The analysis of natural microbial populations by ribosomal RNA sequences. *Am. Soc. Microbiol. News* 51:4-12.
66. Gardiner, K.J., T.L. Marsh, and N.R. Pace. (1985). Ion dependence of the *Bacillus subtilis* RNase P reaction. *J. Biol. Chem.* 260:5415-5419.
67. Lane, D.J., D.A. Stahl, G.J. Olsen, D.J. Heller, and N.R. Pace. (1985). A phylogenetic analysis of the genera *Thiobacillus* and *Thiomicrospira* by 5S ribosomal RNA sequences. *J. Bacteriol.* 163:75-81.
68. Marsh, T.L. and N.R. Pace. (1985). RNase P catalysis differs from ribosomal RNA self-splicing. *Science* 229:79-81.
69. Stahl, D.A., D.J. Lane, G.J. Olsen, and N.R. Pace. (1985). Characterization of a Yellowstone hot spring microbial community by 5S ribosomal RNA sequences. *Appl. Environ. Microbiol.* 49:1379-1384.
70. Lane, D.J., B. Pace, G.J. Olsen, D.A. Stahl, M.L. Sogin, and N.R. Pace. (1985). Rapid determination of 16S ribosomal RNA sequences for phylogenetic analyses. *Proc. Natl. Acad. Sci. USA* 82:6955-6959.
71. Olsen, G.J., N.R. Pace, M. Nuell, B.P. Kaine, R. Gupta, and C.R. Woese. (1985). Sequence of the 16S rRNA gene from the thermoacidophilic archaeobacterium *Sulfolobus solfataricus* and its evolutionary implications. *J. Mol. Evol.* 22:301-307.
72. Marsh, T.L., B. Pace, C. Reich, K. Gardiner, and N.R. Pace. (1985). Processing of tRNA precursors by an RNA catalyst from *Bacillus subtilis*. In "Sequence Specificity in Transcription and Translation," R. Calender, and L. Gold (eds.). Alan R. Liss, Inc. pp. 441-450.
73. Pace, N.R., and T.L. Marsh. (1986). RNA catalysis and the origin of life. *Origins of Life* 16:97-116.
74. Pace, N.R., D.A. Stahl, D.J. Lane, and G.J. Olsen. (1986). The analysis of natural microbial populations by ribosomal RNA sequences. *Adv. Microbial Ecol.* 9:1-55.
75. Waugh, D.S., and N.R. Pace. (1986). Catalysis by RNA. *BioEssays* 4:56-61.
76. Olsen, G.J., D.J. Lane, S.J. Giovannoni, D.A. Stahl, and N.R. Pace. (1986). Microbial ecology and evolution: a ribosomal RNA approach. *Ann. Rev. Microbiol.* 40:337-365.
77. Leichtling, B.H., H.V. Rickenberg, R.J. Seely, D.E. Fahrney, and N.R. Pace. (1986). The occurrence of cyclic AMP in archaeobacteria. *Biochem. Biophys. Res. Comm.* 136:1078-1082.
78. Reich, C., K. Gardiner, B. Pace, G.J. Olsen, T.L. Marsh, and N.R. Pace. (1986). The RNA component of the *Bacillus subtilis* RNase P: sequence, activity and partial secondary structure. *J. Biol. Chem.* 261:7888-7893.
79. Pace, N.R., G.J. Olsen, and C.R. Woese. (1986). Ribosomal RNA phylogeny and the primary lines of evolutionary descent. *Cell* 45:325-326.
80. Pace, N.R., D.J. Lane, G.J. Olsen, and D.A. Stahl. (1986). Phylogenetic analysis of organisms and populations using ribosomal RNA sequences. *Proc. Fourth Internatl. Symp. on Microbial Ecology*, pp. 117-122.

81. Woese, C.R., N.R. Pace, and G.J. Olsen. (1986). Are arguments against archaebacteria valid? *Nature* 320:401-402.
82. Stahl, D.A., D.J. Lane, G.J. Olsen, D.J. Heller, T.M. Schmidt, and N.R. Pace. (1987). A phylogenetic analysis of certain sulfide-oxidizing and related morphologically conspicuous bacteria by 5S ribosomal RNA sequences. *Internatl. J. Syst. Bacteriol.* 37:116-122.
83. Pace, N.R., B.D. James, C. Reich, D.S. Waugh, G.J. Olsen, and T.L. Marsh. (1987). *Bacillus subtilis* RNase P. In "Molecular Biology of RNA: New Perspectives," M. Inouye, and B. Dudock (eds.), Academic Press, pp. 17-36.
84. Romaniuk, P.J., B. Zoltowska, T.J. Trust, D.J. Lane, G.J. Olsen, N.R. Pace, and D.J. Stahl. (1987). *Campylobacter pylori*, the spiral bacterium associated with human gastritis, is not a true *Campylobacter* sp. *J. Bacteriol.* 169:2137-2141.
85. Pace, N.R., C. Reich, B.D. James, G.J. Olsen, B. Pace, and D.S. Waugh. (1987). Structure and catalytic function in ribonuclease P. *Cold Spring Harbor Symp. Quant. Biol.* 52:239-248.
86. Lane, D.J., K.G. Field, G.J. Olsen, and N.R. Pace. (1988). Reverse transcriptase sequencing of rRNA for phylogenetic analysis. *Meth. Enzymol.* 167:138-144.
87. Field, K.G., G.J. Olsen, D.J. Lane, S.J. Giovannoni, M.T. Ghiselin, E.C. Raff, N.R. Pace, and R.A. Raff. (1988). Molecular phylogeny of the animal kingdom based on 18S ribosomal RNA sequences. *Science* 239:748-753.
88. Karl, D.M., G.T. Taylor, J.A. Novitsky, H.W. Jannasch, C.O. Wirsen, N.R. Pace, D.J. Lane, G.J. Olsen, and S.J. Giovannoni. (1988). A microbiological study of Guaymas Basin high temperature hydrothermal vents. *Deep-Sea Research* 35:777-791.
89. James, B.D., G.J. Olsen, J. Liu, and N.R. Pace. (1988). The secondary structure of ribonuclease P RNA, the catalytic element of a ribonucleoprotein enzyme. *Cell* 52:19-26.
90. Reich, C., G.J. Olsen, B. Pace, and N.R. Pace. (1988). The role of the protein moiety of ribonuclease P, a catalytic ribonucleoprotein. *Science* 239:178-181.
91. Turner, S., E.F. DeLong, S.J. Giovannoni, G.J. Olsen, and N.R. Pace. (1988). Phylogenetic analysis of microorganisms and natural populations using ribosomal RNA sequences. In "Microbial Mats: Ecological Physiology of Benthic Microbial Communities," Y. Cohen, and E. Rosenberg (eds.), *Am. Soc. Microbiol.*, pp. 390-401.
92. Giovannoni, S.J., E.F. DeLong, G.J. Olsen, and N.R. Pace. (1988). Phylogenetic group-specific nucleic acid probes for identification of single microbial cells. *J. Bacteriol.* 170:720-726.
93. Distel, D.L., D.J. Lane, G.J. Olsen, S.J. Giovannoni, B. Pace, N.R. Pace, D.A. Stahl, and H. Felbeck. (1988). Sulfur metabolizing bacterial endosymbionts: analysis of phylogeny, specificity and origins by 16S ribosomal RNA sequences. *J. Bacteriol.* 170:2506-2510.
94. Giovannoni, S.J., S. Turner, G.J. Olsen, D.J. Lane, and N.R. Pace. (1988). Evolutionary relationships among cyanobacteria and green chloroplasts. *J. Bacteriol.* 170:3584-3592.
95. James, B.D., G.J. Olsen, and N.R. Pace. (1989). Phylogenetic comparative analysis of RNA secondary structure. *Meth. Enzymol.* 180:227-239.
96. Raff, R.A., K.G. Field, G.J. Olsen, S.J. Giovannoni, D.J. Lane, M.T. Ghiselin, N.R. Pace, and E.C. Raff. (1989). Metazoan phylogeny based on analysis of 18S ribosomal RNA. In "The Hierarchy of Life," B. Fernholm, K. Bremer, and H. Jörnvall (eds.), Elsevier Science Publishers B.V., pp. 247-260.

97. Turner, S., T. Burger-Wiersma, S.J. Giovannoni, L.R. Mur, and N.R. Pace. (1989). The relationship of a prochlorophyte, *Prochlorothrix hollandica*, to green chloroplasts. *Nature* 337:380-382.
98. Pace, N.R., D.K. Smith, G.J. Olsen, and B.D. James. (1989). Phylogenetic comparative analysis and the secondary structure of ribonuclease P RNA. *Gene* 82:65-75.
99. DeLong, E.F., G.S. Wickham, and N.R. Pace. (1989). Phylogenetic stains: ribosomal RNA-based probes for the identification of single cells. *Science* 243:1360-1363.
100. Waugh, D.S., C.J. Green, and N.R. Pace. (1989). The design and catalytic properties of a simplified ribonuclease P RNA. *Science* 244:1569-1572.
101. Pace, N.R., and B. Pace. (1990). A ribosomal RNA terminal maturase: Ribonuclease M5 from *Bacillus subtilis*. *Meth. Enzymol.* 181:366-374.
102. Burgin, A.B., K. Parodos, D.J. Lane, and N.R. Pace. (1990). The excision of intervening sequences from *Salmonella* 23S ribosomal RNA. *Cell* 60: 405-414.
103. Pace, N.R., and D. Smith. (1990). Ribonuclease P: function and variation. *J. Biol. Chem.* 265:3587-3590.
104. Pace, N.R. and A.B. Burgin. (1990). Processing and evolution of the ribosomal RNAs. In "The Structure, Function and Evolution of Ribosomes," W. E. Hill, A. Dahlberg, R.A. Garrett, P.B. Moore, D. Schlessinger, and J.R. Warner (eds.), *Am. Soc. Microbiol.*, pp. 417- 425.
105. DeLong, E.F., T.M. Schmidt, and N.R. Pace. (1990). Analysis of single cells and oligotrophic picoplankton populations using 16S ribosomal RNA sequences. In "Recent Advances in Microbial Ecology," T. Hatori, Y. Ishida, Y. Maruyama, R. Morita, and A. Uchida (eds.), *Japan Scientific Societies Press*, pp. 697-701.
106. Giovannoni, S.J., E.F. DeLong, T.M. Schmidt, and N.R. Pace. (1990). Tangential flow filtration and preliminary phylogenetic analysis of marine picoplankton. *Appl. Environ. Microbiol.* 56:2572-2575.
107. Darr, S.C., Pace, B., and N.R. Pace. (1990). Characterization of ribonuclease P from the archaebacterium *Sulfolobus solfataricus*. *J. Biol. Chem.* 265:12927-12932.
108. Brown, J.W., D.A. Hunt, and N.R. Pace. (1990). Nucleotide sequence of the 10Sa RNA gene of the b-purple eubacterium *Alcaligenes eutrophus*. *Nucleic Acids Res.* 18:2820.
109. Waugh, D.S., and N.R. Pace. (1990). Complementation of a thermoinducible RNase P RNA (*rnpB*) gene deletion in *Escherichia coli* by homologous genes from distantly related eubacteria. *J. Bacteriol.* 172:6316-6322.
110. Burgin, A., and N.R. Pace. (1990). Mapping the active site of ribonuclease P RNA using a substrate containing a photoaffinity agent. *EMBO J.* 9:4111-4118.
111. Schmidt, T.M., E.F. DeLong, and N.R. Pace. (1991). Phylogenetic identification of uncultivated microorganisms in natural habitats. In "Rapid Methods and Automation in Microbiology and Immunology," A. Vaheri, R.C. Tilton, and A. Balows (eds.), *Springer-Verlag*, pp. 37-46.
112. Pace, N.R., and D.S. Waugh. (1991). The design of a simplified ribonuclease P RNA by phylogenetic comparison. *Meth. Enzymol.* 203:500-510.
113. Eden, P.A., T.M. Schmidt, R.P. Blakemore, and N.R. Pace. (1991). Phylogenetic analysis of *Aquaspirillum magnetotacticum* using PCR-amplified 16S ribosomal RNA-specific DNA. *Internatl. J. Syst. Bacteriol.* 41:324-325.

114. Schmidt, T.M., B. Pace, and N.R. Pace. (1991). Detection of DNA contamination in *Taq* polymerase. *BioTechniques* 11:176-177.
115. Brown, J.W., and N.R. Pace. (1991). Structure and evolution of ribonuclease P RNA. *Biochimie* 73:689-697.
116. Brown, J.W., E.S. Haas, B.D. James, D.A. Hunt, J. Liu, and N.R. Pace. (1991). Phylogenetic analysis of ribonuclease P RNA structure in proteobacteria. *J. Bacteriol.* 173:3855-3863.
117. Schmidt, T.M., E.F. DeLong, and N.R. Pace. (1991). Analysis of a marine picoplankton community using 16S rRNA gene cloning and sequencing. *J. Bacteriol.* 173:4371-4378.
118. Pace, N.R. (1991). Origin of life--Facing up to the physical setting. *Cell* 65:531-533.
119. Haas, E.S., D. Morse, J. W. Brown, F.J. Schmidt, and N.R. Pace. (1991). Sequence covariation reveals new long-range structure in ribonuclease P RNA. *Science* 254:853-856.
120. Smith, D., A. Burgin, E. Haas, and N.R. Pace. (1992). Influence of metal ions on the ribonuclease P reaction: Distinguishing catalytic effects from binding. *J. Biol. Chem.* 267:2429-2436.
121. Darr, S.C., K. Zitto, D. Smith, and N.R. Pace. (1992). Contributions of phylogenetically variable structural elements to the function of the ribozyme ribonuclease P. *Biochemistry* 31:328-333.
122. Wilmotte, A., S. Turner, Y. Van de Peer, and N.R. Pace. (1992). Taxonomical study of marine oscillatorian strains (Cyanophyceae, cyanobacteria) with narrow trichomes. II. Nucleotide sequence analysis of the 16S ribosomal RNA. *J. Phycol.* 28:828-838.
123. Banta, A.B., E.S. Haas, J.W. Brown, and N.R. Pace. (1992). Sequence of the ribonuclease P RNA gene from the cyanobacterium *Anacystis nidulans*. *Nucleic Acids Res.* 20:911.
124. Brown, J.W., and N. R. Pace. (1992). Ribonuclease P RNA and protein subunits from bacteria. *Nucleic Acids Res.* 20:1451-1456.
125. Lane, D.J., A.P. Harrison, D. Stahl, B. Pace, S.J. Giovannoni, G.J. Olsen, and N.R. Pace. (1992). Evolutionary relationships among sulfur- and iron-oxidizing eubacteria. *J. Bacteriol.* 174:269-278.
126. Darr, S.C., J. W. Brown, and N.R. Pace. (1992). The varieties of ribonuclease P. *Trends Biochem. Sci.* 17:178-182.
127. Pace, N.R. (1992). New Horizons for RNA Catalysis. *Science* 256:1402-1403.
128. Reysenbach, A.-L., L.J. Giver, G.S. Wickham, and N.R. Pace. (1992). Differential amplification of ribosomal RNA genes by PCR. *Appl. Environ. Microbiol.* 58:3417-3418.
129. Smith, D., and N.R. Pace. (1993). Multiple magnesium ions in the ribonuclease P reaction mechanism. *Biochemistry* 32:5273-5281.
130. Waugh, D.S., and N.R. Pace. (1993). Gap-scan deletion analysis of *Bacillus subtilis* RNase P RNA. *FASEB J.* 7:188-195.
131. Durand, P., A.-L. Reysenbach, D. Prieur, and N.R. Pace. (1993). Isolation and characterization of *Thiobacillus hydrothermalis* sp. nov., a mesophilic obligately chemolithotrophic bacterium isolated from a deep sea hydrothermal vent in Fiji Basin. *Arch. Microbiol.* 159:39-44.
132. Brown, J.W., E.S. Haas, and N.R. Pace. (1993). Characterization of ribonuclease P RNAs from thermophilic bacteria. *Nucleic Acids Res.* 21:671-679.

133. Angert, E.R., K.D. Clements, and N.R. Pace. (1993). The largest bacterium. *Nature* 362:239-241.
134. Woese, C.R., and N.R. Pace. (1993). Probing RNA structure, function and history by comparative analysis. In "The RNA World," R. Gesteland, and J. Atkins (eds.), Cold Spring Harbor Press, pp. 91-117.
135. Nolan, J.M., D.H. Burke, and N.R. Pace. (1993). Circularly permuted tRNAs as specific photoaffinity probes of ribonuclease P structure. *Science* 261:762-765.
136. Erauso, G., A.-L. Reysenbach, B. Crump, F. Partensky, J.A. Baross, V.T. Marteinsson, N.R. Pace, and D. Prieur. (1993). *Pyrococcus fijiensis* sp. nov., a new hyperthermophilic archaeon isolated from a deep sea hydrothermal vent. *Arch. Microbiol.* 160:338-349.
137. LaGrandeur, T., S. Darr, E. Haas, and N.R. Pace. (1993). Characterization of the RNase P RNA of *Sulfolobus acidocaldarius*. *Bacteriol.* 175:5043-5048.
138. Pace, N.R., E.R. Angert, E.F. DeLong, T.M. Schmidt, and G.S. Wickham. (1993). New perspective on the natural microbial world. In "Industrial Microorganisms: Basic & Appl. Molec. Genetics," R.H. Baltz, G. D. Hegeman, and P.L. Skatrud (eds.), American Society for Microbiology Press, pp. 77-83.
139. Zito, K., A. Huttenhofer, and N. R. Pace. (1993). Lead-catalyzed cleavage of ribonuclease P RNA as a probe for integrity of tertiary structure. *Nucleic Acids Res.* 21:5916-5920.
140. Barns, S.M., R.E. Fundyga, M.W. Jeffries, and N.R. Pace. (1994). Remarkable archaeal diversity in a Yellowstone Hot Spring Environment. *Proc. Natl. Acad. Sci. USA* 91:1609-1613.
141. Haas, E.S., J.W. Brown, C. Pitulle, and N.R. Pace. (1994). Further perspective on the catalytic core and secondary structure of ribonuclease P RNA. *Proc. Natl. Acad. Sci. USA* 91:2527-2531.
142. Reysenbach, A.-L., G.S. Wickham, and N.R. Pace. (1994). Phylogenetic analysis of the hyperthermophilic "pink filament" community in Octopus Spring, Yellowstone National Park. *Appl. Environ. Microbiol.* 60:2113-2119.
143. Harris, M.E., J.M. Nolan, A. Malhotra, J.W. Brown, S.C. Harvey, and N.R. Pace. (1994). Use of Photoaffinity crosslinking and molecular modeling to analyze the global architecture of ribonuclease P RNA. *EMBO J.* 13:3953-3963.
144. LaGrandeur, T.E., A. Huttenhofer, H.F. Noller, and N.R. Pace. (1994). Phylogenetic-comparative chemical footprint analysis of the interaction between ribonuclease P RNA and tRNA. *EMBO J.* 13:3945-3952.
145. Oh, B.-K. and N.R. Pace. (1994). Interaction of the 3'-end of tRNA with ribonuclease P RNA. *Nucleic Acids Res.* 22: 4087-4094.
146. Frank, D.N., M.E. Harris, and N.R. Pace. (1994). Rational design of self-cleaving pre-tRNA - ribonuclease P conjugates. *Biochemistry* 33:10800-10808.
147. Brown, J.W., E.S. Haas, D.G. Gilbert, and N.R. Pace. (1994). The ribonuclease P database. *Nucleic Acids Res.* 22:3660-3662.
148. Reysenbach, A.-L., and N.R. Pace. (1994). Reliable amplification of hyperthermophilic archaeal 16S rRNA genes by the polymerase chain reaction. In "Archaea - A Laboratory Manual: Thermophiles," F.T. Robb *et al.* (eds.), Cold Spring Harbor Laboratory Press, pp. 101-105.
149. Pace, N.R., and J.W. Brown. (1995). Evolutionary perspective on the structure and function of ribonuclease P, a ribozyme. *J. Bacteriol.* 177:1919-1928.

150. Harris, M.E., and N.R. Pace. (1995). Identification of phosphates involved in catalysis by the ribozyme RNase P RNA. *RNA* 1:210-218.
151. Jeanthnon, C., A.-L. Reysenbach, S. Haridon, A. Gambacorta, N.R. Pace, P. Glenat, and D. Prieur. (1995). *Thermotoga subterranea* sp. nov., a new thermophilic bacterium isolated from a continental oil reservoir. *Arch. Microbiol.* 164:91-97.
152. Pagan-Ramos, E., A.J. Trangguch, J.M. Nolan, N.R. Pace, and D.R. Engelke. (1995). Analysis of conserved positions in nuclear RNase P RNA. *Nucl. Acids Symp. Series* 33:89-91.
153. Nolan, J., and N.R. Pace. (1996). Structural analysis of the bacterial ribonuclease P RNA. *Nucl. Acids and Mol. Biol.* 10:109-128.
154. Harris, M.E., and N.R. Pace (1996). Analysis of the tertiary structure of bacterial RNase P RNA. *Mol. Biol. Reports* 22:115-123.
155. Brown, J.W., J.M. Nolan, E.S. Haas, M.A. Rubio, F. Major, and N.R. Pace. (1996). Comparative analysis of ribonuclease P RNA using gene sequences from natural microbial populations reveals tertiary structural elements. *Proc. Natl. Acad. Sci. USA* 93:3001-3006.
156. Barns, S.M., C.F. Delwiche, J.D. Palmer, and N.R. Pace. (1996). Perspectives on archaeal diversity, thermophily and monophyly from environmental rRNA sequences. *Proc. Natl. Acad. Sci. USA* 93:9188-9193.
157. Siegel, R.W., A.B. Banta, E.S. Haas, J.W. Brown, and N.R. Pace. (1996) *Mycoplasma fermentans* simplifies our view of the catalytic core of the ribonuclease P RNA. *RNA* 2:452-462.
158. Hugenholtz, P., and N.R. Pace. (1996). A molecular phylogenetic approach to the natural microbial world: the biotechnological potential. *Trends Biotechnol.* 14:190-197.
159. Rajan, J., K. Dudekula, R.E. Perkins, S. Sariaslani, S.M. Barns, A.-L. Reysenbach, S. Rehm, M. Ehringer, and N.R. Pace. (1996). Mineralization of 2,4,6-trinitrophenol (picric acid): Characterization and phylogenetic identification of microbial strains. *J. Industrial Microbiol.* 16:319-324.
160. Angert, E.R., A.E. Brooks, and N.R. Pace. (1996) Phylogenetic analysis of *Metabacterium polyspora*: clues to the evolutionary origin of daughter cells in *Epulopiscium* species, the largest bacteria. *J. Bacteriol.* 178:1451-1456.
161. Pace, N.R. (1996). New perspective on the natural microbial world: molecular microbial ecology. *ASM News* 62:463-470.
162. Frank, D.N., A.E. Ellington, and N.R. Pace. (1996). *In vitro* selection of RNase P RNA reveals optimized catalytic activity in a highly conserved structural domain. *RNA* 2:1179-1188.
163. Hershberger, K.L., S.M. Barns, A.-L. Reysenbach, S. Dawson, and N.R. Pace. (1996). Wide diversity of Crenarchaeota. *Nature* 384:420.
164. Haas, E.S., A.B. Banta, J.K. Harris, N.R. Pace, and J.W. Brown. (1996). Structure and evolution of ribonuclease P RNA in Gram-positive Bacteria. *Nucleic Acids Res.* 24:4790-4798.
165. Barns, S.M., C.F. Delwiche, J.D. Palmer, S.C. Dawson, K.L. Hershberger, and N.R. Pace. (1996). Phylogenetic perspective on microbial life in hydrothermal ecosystems, past and present. In "Evolution of Hydrothermal Ecosystems on Earth (and Mars?)," G.R. Bock, and J.A. Goode (eds.), Wiley Press, Chichester, pp. 24-32.
166. Pace, N.R. (1997). Opening the door onto the natural microbial world: molecular microbial ecology. *The Harvey Lectures*, Series 91:59-78.

167. Harris, M.E., A.V. Kazantsev, J.-L. Chen, and N.R. Pace. (1997). Analysis of the tertiary structure of the ribonuclease P ribozyme-substrate complex by photoaffinity crosslinking. *RNA* 3:561-576.
168. Chen, J.-L., and N.R. Pace. (1997). Identification of the universally conserved core structure of ribonuclease P RNA. *RNA* 3:557-560.
169. Pace, N.R. (1997). A molecular view of microbial diversity and the biosphere. *Science* 276:734-740.
170. Frank, D.N., and N.R. Pace. (1997). *In vitro* selection for altered divalent metal specificity in the RNase P RNA. *Proc. Natl. Acad. Sci. USA* 94:14355-14360.
171. Northup, D.E., A.-L. Reysenbach and N.R. Pace. (1997). Microorganisms and Speleothems. In "Cave Minerals of the World," C. Hill and P. Forti (eds.), National Speleological Society, Huntsville, Alabama, pp. 261-266.
172. Harris, M.E., D.N. Frank, and N.R. Pace. (1998). Structure and catalytic function of the bacterial ribonuclease P ribozyme. In "RNA Structure and Function," R. Simons, and M. Grunberg-Manago (eds.), Cold Spring Harbor Press, pp. 309-337.
173. Hugenholtz, P., C. Pitulle, K.L. Hershberger, and N.R. Pace. (1998). Novel division-level bacterial diversity in a Yellowstone hot spring. *J. Bacteriol.* 180:366-376.
174. Frank, D.N., and N.R. Pace. (1998). Ribonuclease P: unity and diversity in a tRNA processing ribozyme. *Annu. Rev. Biochem.* 67:153-180.
175. Chen, J.-L., J.M. Nolan, M.E. Harris, and N.R. Pace. (1998). Comparative photocross-linking analysis of the tertiary structure of *Escherichia coli* and *Bacillus subtilis* RNase P RNAs. *EMBO J.* 17:1515-1525.
176. Oh, B.-K., D.N. Frank, and N.R. Pace. (1998). Participation of the 3'-CCA of tRNA in the binding of catalytic Mg²⁺ ions by ribonuclease P. *Biochemistry* 37(20):7277-7283.
177. Kazantsev, A.V., and N.R. Pace. (1998). Identification by modification-interference of purine N-7 and ribose 2'-OH groups critical for catalysis by bacterial ribonuclease P. *RNA* 4:937-947.
178. Pitulle, C., M. Garcia-Paris, K.R. Zamudio, and N.R. Pace. (1998). Comparative structure analysis of vertebrate ribonuclease P RNA. *Nucleic Acids Res.* 26: 3333-3339.
179. Angert, E.R., D.E. Northup, A.-L. Reysenbach, A.S. Peek, B.M. Goebel, and N.R. Pace. (1998). Molecular phylogenetic analysis of a bacterial community in Sulfur River, Parker Cave, Kentucky. *American Mineralogist* 83(11-12,pt 2):1583- 1592.
180. Tanner, M.A., B.M. Goebel, and N.R. Pace. (1998). Specific ribosomal DNA sequences from diverse environmental settings correlate with experimental contaminants. *Appl. Environ. Microbiol.* 64(8):3110-3113.
181. Hugenholtz, P., B.M. Goebel, and N.R. Pace. (1998). Impact of culture-independent studies on the emerging phylogenetic view of microbial diversity. *J. Bacteriol.* 180:4765-4774.
182. Dojka, M.A., P. Hugenholtz, S.K. Haack, and N.R. Pace. (1998). Microbial diversity in a hydrocarbon and chlorinated solvent-contaminated aquifer undergoing intrinsic bioremediation. *Appl. Environ. Microbiol.* 64(10):3869-3877.
183. Sandler, S.J., P. Hugenholtz, C. Schleper, E.F. Delong, N.R. Pace, and A.J. Clark. (1999). Diversity of *radA* genes from cultured and uncultured *Archaea*: comparative analysis of putative RadA proteins and their use as a phylogenetic marker. *J. Bacteriol.* 181:907-915.

184. Tanner, M.A., J.K. Harris, and N.R. Pace. (1999). Molecular phylogeny of *Chlamydia* and relatives. In "Chlamydia: Intracellular Biology, Pathogenesis and Immunity," R.S. Stephens (ed.), American Society for Microbiology, Washington, D.C., pp. 1-8.
185. Pitulle, C. and N.R. Pace. (1999). T-cloning vector for plasmid-based 16s rDNA analysis. *Biotechniques* 26:222-224.
186. Pace, N.R., B.C. Thomas, and C.R. Woese. (1999). Probing RNA structure, function and history by comparative analysis. In "The RNA World, Second Edition," R.F. Gesteland, T.R. Cech and J.F. Atkins (eds.), Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y., pp. 113-141.
187. Tanner, M.A., D. Shoskes, A. Shahed, and N.R. Pace. (1999). Prevalence of corynebacterial 16S rRNA sequences in bacterial and "nonbacterial" prostatitis. *J. Clin. Microbiol.* 37:1863-1870.
188. Pace, N.R. (1999). Microbial Ecology and Diversity. *Am. Soc. Microbiology News* 65: 328-333.
189. Edwards, K.J., B.M. Goebel, T.M. Rodgers, M.O. Schrenk, T.M. Gihring, M.M. Cardona, B. Hu, M.M. McGuire, R.J. Hamers and N.R. Pace. (1999). Geomicrobiology of Pyrite Dissolution: Case study at Iron Mountain, California. *Geomicrobiol. J.* 16:155-179.
190. Pace, N.R. (1999). Microbial Diversity and the Biosphere. Pp. 117-129, in "Nature and Human Society: The Quest for a Sustainable World," P. Raven (ed.), National Academy Press, Washington, D.C.
191. Dojka, M.A., J.K. Harris and N.R. Pace. (2000) Expanding the known diversity and environmental distribution of an uncultured phylogenetic division of bacteria. *Appl. Environ. Microbiol.* 66:1617-1621.
192. Pace, N.R. (2000) Community interactions: toward a natural history of the microbial world. *Environmental Microbiol.* 2:7.
193. Thomas, B.C., A.V. Kazantsev, J.-L. Chen and N.R. Pace (2000) Photoaffinity cross-linking and RNA structure analysis. *Meth. Enzymol.* 318:136-147.
194. Frank, D.N., C. Adamidi, M.A. Ehringer, C. Pitulle and N.R. Pace (2000) Phylogenetic-comparative analysis of the eucaryal ribonuclease P RNA. *RNA*, 6:1895-1904.
195. Dawson, S.C., E.F. DeLong and N.R. Pace (2000) Phylogenetic and ecological perspectives on uncultured Crenarchaeota and Korarchaeota. In M. Dworkin et al., eds., *The Prokaryotes: An Evolving Electronic Database for the Microbiological Community*, 3rd edition (release 3.2), New York, Springer-Verlag, 2000
196. Frank, D.N. and N.R. Pace (2001) Molecular-phylogenetic analyses of human gastrointestinal microbiota. *Curr. Opin. Gastroenterology* , 17:52-57.
197. Shukla, S.K., D.N. Vevea, D.N. Frank, N.R. Pace and K.D. Reed (2001) Isolation and characterization of a black pigmented *Corynebacterium* sp. isolated from a woman with spontaneous abortion: case report and review. *J. Clin. Microbiol. J. Clin. Microbiol.* 39:1109-1113.
198. Pace, N.R. (2001) The universal nature of biochemistry. *Proc. Natl. Acad. Sci. USA* 98:805-808.
199. Kelley, S.T., J.K. Harris and N.R. Pace (2001) Evaluation and refinement of tmRNA structure using gene sequences from natural microbial communities. *RNA*, 7:1310-1316.
200. deSouza, M.P., A. Amini, M.A. Dojka, I.J Pickering, S.C. Dawson, N.R. Pace and N. Terry (2001) Identification and characterization of bacteria in a selenium-contaminated hypersaline evaporation pond. *Appl. Environ. Microbiol* 67: 3785-3794.

201. DeLong, E.F. and N.R. Pace (2001) Environmental diversity of Bacteria and Archaea. *Systematic Biology* 50(4):470-478
202. Barton, H.A., J.R. Spear and N.R. Pace. (2001) Microbial life in the underworld: Biogenicity in secondary mineral formations. *Geomicrobiol. J.* 18:359-368.
203. Spear, J.R., J.J. Walker, S.M. Barns and N.R. Pace. (2002) A search for life in Yellowstone's Well Y-7: A portal to the subsurface. *Yellowstone Science* 9:15-21.
204. Krivenko, A.A., A.V. Kazantsev, C. Adamidi, D.J. Harrington and N.R. Pace. (2002) Expression, purification, crystallization and preliminary diffraction analysis of RNase P protein from *Thermotoga maritima*. *Acta. Crystallogr. D Biol. Crystallogr.* 58:1234-6.
205. Blank, C.E., S.L. Cady, and N.R. Pace. (2002) Microbial composition of near-boiling silica-depositing thermal springs throughout Yellowstone National Park. *Appl. Environ. Microbiol.* 68:5123-35.
206. McMahon, K.D., M.A. Dojka, N.R. Pace, D. Jenkins and J.D. Keasling. (2002) Polyphosphate kinase from activated sludge performing enhanced biological phosphorus removal. *Appl. Environ. Microbiol.* 68:4971-4978.
207. Dawson, S.C. and N.R. Pace. (2002) Novel kingdom-level eukaryotic diversity in anoxic environments. *Proc. Natl. Acad. Sci. USA* 99:8324-8329. r
208. Li, X., D.N. Frank, N.R. Pace, J.M. Zengel. (2002) Phylogenetic analysis of the structure of RNase MRP RNA in yeasts. *RNA* 8:741-751.
209. Frank, D.N., G.B. Spiegelman, W. Davis, E. Wagner, E. Lyons and N.R. Pace. (2003) Culture-independent molecular analysis of microbial constituents of the healthy human outer ear. *J. Clin. Microbiol.* 41:295-303.
210. Harris, J.K., S.T. Kelley, G.B. Spiegelman and N.R. Pace. (2003) The genetic core of the universal ancestor. *Genome Res.* 13:407-412, 2003.
211. Spear, J.R., R.E. Ley, A.B. Berger and N.R. Pace. (2003) Complexity in natural microbial ecosystems: the Guerrero Negro experience. *Biol. Bull.* 204:168-173.
212. Torre, J.R. de la, B.M. Goebel, E.I. Friedmann and N.R. Pace. (2003) Microbial diversity of cryptoendolithic communities from the McMurdo dry valleys, Antarctica. *Appl. Environ. Microbiol.*, 69:3858-3867.
213. Kazantsev, A.V., A.A. Krivenko, D.J. Harrington, R.J. Carter, S.R. Holbrook, P.D. Adams and N.R. Pace. (2003) High-resolution structure of RNase P protein from *Thermotoga maritima*. *Proc. Natl. Acad. Sci. USA* 100:7497-7502.
214. Pace, N.R. (2004) The early branches in the tree of life. In "Assembling the Tree of Life," J. Cracraft and M.J. Donoghue, eds., pp. 76-85 (Oxford University Press, New York).
215. Pace, N.R. (2005) The large-scale structure of the tree of life. In "Microbial Evolution: Concepts and Controversies," J. Sapp, ed, pp. 53-69 (Oxford University Press, New York).
216. Harris, J.K., S.T. Kelley and N.R. Pace (2004) New perspective on an uncultured bacterial phylogenetic division. *Appl. Environ. Microbiol.* 70:845-849.
217. Kelley, S.T., U. Theisen, L. Angenent, A. St. Amand and N. R. Pace. (2004) Molecular analysis of shower curtain microbes. *Appl. Environ. Microbiol.* 70:4187-4192.

218. Barton, H.A., M.R. Taylor and N.R. Pace. (2004) Molecular phylogenetic analysis of a bacterial community in an oligotrophic cave environment. *Geomicrobiol. J.* 21:11-20.
219. Spear, J.R. and N.R. Pace. (2004) Diversity of life at the geothermal subsurface-surface interface: The Yellowstone example. Pp. 343-354 in "The Subsurface Seafloor Biosphere at Mid-Ocean Ridges. Wilcok, W.S.D. *et al.* eds. Geophysical Monograph Series 144 (Am. Geophysical Union, Washington, DC).
220. Spear, J.R., J.J. Walker, T. McCollom and N.R. Pace. (2005) Hydrogen and bioenergetics in a geothermal ecosystem. *Proc. Natl. Acad. Sci. USA* 102:2555-2560.
221. Marquez, S.M., J.K. Harris, S.T. Kelley, E. Roberts and N.R. Pace. (2005) Structural implications of new kingdom-level diversity in eucaryal RNase P RNA. *RNA* 11:739-751.
222. Angenent, L.T., S.T. Kelley, A. St. Amand, N.R. Pace and M.T. Hernandez. (2005) Molecular identification of potential pathogens in water and air of a hospital therapy pool. *Proc. Natl. Acad. Sci. USA* 102:4860-4865.
223. DeGroote, M.A., D.N. Frank, E. Dowell, M.P. Glode and N.R. Pace. (2005) *Lactobacillus rhamnosis* GG bacteremia associated with probiotic use in a child with short gut syndrome. *Pediatric Infect. Disease J.* 24:278-280.
224. St. Amand, D.N. Frank, M.A. DeGroote and N.R. Pace. (2005) Microscopic detection of *Mycobacterium avium* complex organisms in tissue with specific rRNA oligonucleotide probes. *J. Clin. Microbiol.* 43:1505-1514.
225. Walker, J.J., J.R. Spear and N.R. Pace. (2005) A novel endolithic microbial community in the Yellowstone geothermal environment. *Nature* 434:1011-1014.
226. Buck, A., A.B. Dalby, A.W. Poole, A.V. Kazantsev and N.R. Pace. (2005) Protein activation of a ribozyme: the role of bacterial RNase P protein. *EMBO J.* 24:3360-3368.
227. St. Amand, A.L., D.N. Frank, M.A. DeGroote, R.J. Basaraba, I.M. Orme and N.R. Pace. (2005) Microscopic detection of *Mycobacterium tuberculosis* in culture and tissue with specific rRNA oligonucleotide probes. *J. Clin. Microbiol.* 43:5369-5371.
228. Kazantsev, A.V., A.A. Krivenko, D.J. Harrington, S.R. Holbrook and N.R. Pace. (2005) Crystal structure of a bacterial ribonuclease P RNA. *Proc. Natl. Acad. Sci. USA* 102:13392-13397.
229. Gardner, E.M., W.J. Burman, M.A. DeGroote, G. Hildred and N.R. Pace. (2005) Conventional and molecular epidemiology of macrolide resistance among new *Mycobacterium avium* complex isolates recovered from HIV-infected patients. *Clin. Infect. Dis.* 41:1041-1044.
230. Buck, A.H., A.V. Kazantsev, A.B. Dalby and N.R. Pace. (2005) Structural perspective on the activation of RNase P RNA by protein. *Nature Struct. Mol. Biol.* 12:958-964.
231. Robertson, C.E., J.K. Harris, J.R. Spear and N.R. Pace. (2005) Phylogenetic diversity and ecology of environmental archaea. *Curr. Opin. Microbiol.* 8:638-642.
232. Papineau, D., J.J. Walker, S.J. Mojzsis and N.R. Pace. (2005) Composition and structure of microbial communities from stromatolites of Hamelin Pool in Shark Bay, Western Australia. *Appl. Environ. Microbiol.* 71:4822-4832.
233. Frank, D.N. and N.R. Pace. (2005) Another ribosomal RNA sequence milestone-and a call for better annotation. *ASM News* 71:501-502.
234. Spear, R.R., J.J. Walker and N.R. Pace. (2005) Hydrogen and primary productivity: Inference of biogeochemistry from phylogeny in a geothermal ecosystem, pp. 113-128, in "Geothermal Biology and Geochemistry in Yellowstone National Park," W.P. Inskeep and T.R. MacDermott, eds. (Montana State University Press).

235. Ley, R.E., J.K. Harris, J. Wilcox, J.R. Spear, S.R. Miller, B.M. Bebout, J.A. Maresca, D.A. Bryant and N.R. Pace. (2006) Unexpected diversity and complexity from the Guerrero Negro hypersaline microbial mat. *Appl. Environ. Microbiol.* 72:3685-3695.
236. Salmassi, T.M., J.J. Walker, D.K. Newman, J.R. Leadbetter, N.R. Pace and J.G. Hering. (2006) Community and cultivation analysis of arsenite oxidizing biofilms at Hot Creek. *Environ. Microbiol.* 8:50-59.
237. Evans, D., S.M. Marquez and N.R. Pace. (2006) RNase P: Interface of the RNA and protein worlds. *Trends Biochem. Sci.* 31:333-341.
238. Spear, J.R., J.J. Walker and N.R. Pace. (2006) Microbial ecology and energetics in Yellowstone Hot Springs. *Yellowstone Science* 14:17-24.
239. Pace, N.R. (2006) Time for a change. *Nature* 441:289.
240. Dalby, A.B., D.N. Frank, A.L. St. Amand, A.M. Bendele and N.R. Pace. (2006) Culture-independent analysis of indomethacin-induced alterations in rat gastrointestinal microbiota. *Appl. Environ. Microbiol.* 72:6707-6715.
241. Kazantsev, A.V. and N.R. Pace. (2006) Bacterial RNase P: a new view of an ancient enzyme. *Nature Rev. Microbiol.* 4: 729-740.
242. De Groote, M.A., N.R. Pace and J.O. Falkinham III. (2006) Relationships between *Mycobacterium* isolates from patients with pulmonary mycobacterial infection and potting soils. *Appl. Environ. Microbiol.* 72:7602-7606.
243. Marquez, S.M., J. Chen, D. Evans and N.R. Pace. (2006) Structure and function of eukaryotic ribonuclease P RNA. *Molecular Cell* 24:445-456.
244. Walker, J.J. and N.R. Pace. (2007) Endolithic microbial Ecosystems. *Annu. Rev. Microbiology* 61:331-347.
245. Spear, J.R., H.A. Barton, C.E. Robertson, C.A. Francis and N.R. Pace. (2007) Microbial Community biofabrics in a geothermal mine adit. *Appl. Environ. Microbiol.* 73:6172-6180.
246. Walker, J.J. and N.R. Pace. (2007) Phylogenetic composition of Rocky Mountain endolithic ecosystems. *Appl. Environ. Microbiol.* 73:3497-3504.
247. Frank, D.N., A.L. St. Amand, R.A. Feldman, E.C. Boedeker, N. Harpaz and N.R. Pace. (2007) Molecular –phylogenetic characterization of microbial community imbalances in human inflammatory bowel diseases. *Proc. Natl. Acad. Sci. USA* 104:13780-13785.
248. Baumgartner, L. and N.R. Pace. (2007) Current taxonomy in classroom instruction: How to teach the new understanding of higher-level taxonomy. *The Science Teacher* 74:46-51.
249. Harris, J.K., M.A. DeGroote, S.D. Sagel, E.T. Zemanick, R. Kapsner, C. Pencari, H. Kaess, R.R. Deterding, F.J. Accurso and N. R. Pace. (2007) Molecular identification of bacteria in bronchoalveolar lavage fluid from children with cystic fibrosis. *Proc. Natl. Acad. Sci. USA* 104:20529-20533.
250. Pace, N.R. (2008) The molecular tree of life changes how we see, teach microbial diversity. *Microbe* 3:15-20.
251. Frank, D.N and N.R. Pace. (2008) Gastrointestinal microbiology enters the metagenomic era. *Curr. Opin. Gastroenterology* 24:4-10.
252. Feazel, L.M., J.R. Spear, A.B. Berger, J.K. Harris, D.N. Frank, R.E. Ley and N.R. Pace. (2008) Eucaryotic diversity in a hypersaline microbial Mat. *Appl. Environ. Microbiol.* 74:329-332.

253. Kunin, V., J. Raes, J.K. Harris, J.R. Spear, J.J., Walker, N. Ivanova, C. von Mering, B.M. Bebout, N.R. Pace, P. Bork and P. Hugenholtz. (2008) Millimeter-scale genetic gradients and community-level molecular convergence in a hypersaline microbial mat. *Molecular Systems Biology* 4: Art. 198, 1-6.
254. Sahl, J.W., N.R. Pace and J.R. Spear. (2008) Comparative molecular analysis of endoevaporitic microbial communities. *Appl. Environ. Microbiol.* 74:6444-6446.
255. Peterson, D.A., D.N. Frank, N.R. Pace and J.I. Gordon. (2008) Metagenomic approaches for defining the pathogenesis of inflammatory bowel disease. *Cell Host Microbe* 3:417-427.
256. Kazantsev, A.V., A.A. Krivenko and N.R. Pace. (2009) Mapping metal-binding sites in the catalytic domain of bacterial RNase P RNA. *RNA* 15:266-276.
257. Robertson, C.E., J.R. Spear, J.K. Harris and N.R. Pace (2009) Diversity and stratification of archaea in a hypersaline microbial mat. *Appl. Environ. Microbiol.* 75:1801-1810.
258. Frank, D.N., A. Wysocki, D.D. Specht-Glick, A. Rooney, R.A. Feldman, A.L. St. Amand, N.R. Pace and J.D. Trent. (2009) Microbial Diversity in chronic open wounds. *Wound Rep. Reg.* 17:163-172.
259. Pace, N.R. (2009) Problems with procaryote. *J. Bacteriol.* 191:2008-2010.
260. Pace, N.R. (2009) Rebuttal: the modern concept of procaryote. *J. Bacteriol.* 191:2006-2007.
261. Baumgartner, L.K., C. Dupraz, D.H. Buckley, J.R. Spear, N.R. Pace and P.T. Visscher. (2009) Microbial species richness and metabolic activities in hypersaline microbial mats: Insights into biosignature formation through lithification. *Astrobiology* 9:861-874.
262. Baumgartner, L.K., J.R. Spear, D.H. Buckley, N.R. Pace, P. Reid and P.T. Visscher. (2009) Microbial diversity in modern marine stromatolites, Highborne Cay, Bahamas. *Environ. Microbiol.* 11:2710-2719.
263. Pace, N.R. (2009) Mapping the Tree of Life: progress and prospects. *Microbiol. Mol. Biol. Rev.* 73:564-576.
264. Feazel, L.M., L.K. Baumgartner, K.L. Peterson, D.N. Frank, J.K. Harris, and N.R. Pace. (2009) Opportunistic pathogens enriched in showerhead biofilms. *Proc. Natl. Acad. Sci. USA* 106:16393-16399.
265. Frank D.N., S.S. Wilson, A.L. St. Amand, and N.R. Pace. (2009) Culture-independent microbiological analysis of Foley urinary catheter biofilms. *PLoS ONE* 4:e7811 (7 pp.).
266. Rodriguez, M., J.J. Walker, N.R. Pace and M. Hernandez. (2010) Molecular source tracking of bioaerosols in the quarantined Katrina flood zone. *Aerosol Science Technol.* 44:236-245.
267. Frank, D.N., L.M. Feazel, M.T. Bessesen, C.S. Price, E.N. Janoff and N.R. Pace. (2010) The human nasal microbiota and *Staphylococcus aureus* carriage. *PLoS ONE* 5:e10598 (15 pp.).