

Rodolphe BARRANGOU

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a. Professional Preparation

Universite Rene Descartes, Paris V, France	Life Sciences	B.S.	1996
Universite de Technologie Compiegne, France	Biological Engineering	M.S.	2000
North Carolina State University, Raleigh, NC	Food Science	M.S.	2000
North Carolina State University, Raleigh, NC	Functional Genomics	Ph.D.	2004
University of Wisconsin, Madison, WI	Business Administration	M.B.A.	2011

b. Appointments

2016-	Todd R. Klaenhammer Distinguished Scholar in Probiotics Research, NC State
2013-	Associate Professor of Food Science, North Carolina State University, NC
2010-	Adjunct Professor of Food Science, Pennsylvania State University, PA
2011-2013	R&D Director, Genomics, DuPont, WI
2007-2011	Group Manager, Genomics DuPont, WI
2006-2007	Sr. Scientist, Cultures Development, DuPont (Danisco), WI
2005-2006	Scientist, Cultures Development, DuPont (Danisco), WI

NC State University affiliations

- Food, Bioprocessing and Nutrition Sciences (home Department)
- Microbiology graduate program
- Biotechnology graduate program
- Functional Genomics graduate program
- Comparative Medicine Institute

c. Professional Scholarly Activities

2016-	Co-Founder and Chairman of the Scientific Advisory Board, Locus Biosciences
2015-	Editorial Board Member <i>Applied and Environmental Microbiology</i>
2014-	Co-Founder and member of the Scientific Advisory Board, Intellia Therapeutics
2013-2016	Board of Directors and Chairman of the Board, Caribou BioSciences
2007-2012	Co-host and organizer, annual CRISPR meeting, Berkeley CA

d. Honors and awards

2017	National Academy of Sciences Award in Molecular Biology
2016	Canada Gairdner International Award
2016	Warren Alpert Foundation Prize
2016	Todd R. Klaenhammer Distinguished Scholar in Probiotics Research
2016	NC State University John S. Risley Entrepreneur of the year Award

2016 Thomson Reuters Highly Cited Researcher (I-2878-2014)
2015 Thomson Reuters Highly Cited Researcher (I-2878-2014)
2015 NC State University Faculty Scholar
2014 Thomson Reuters Highly Cited Researcher (I-2878-2014)
2014 NC State Alumni Association Outstanding Research Award recipient
2014 Inducted into Phi Tau Sigma, the Honor Society for Food Science
2011 NC State Food Science Outstanding Young Alumni award recipient
2011 Distinguished Lecture in Microbiology, UW-Madison
2010 Sixth Annual Leo W. Parks Distinguished Lecture, NCSU
2009 Danisco Project Management Program
2008 Danisco Innovation Award Recipient
2008 Danisco Americas Management Program
2003 National Science Foundation IGERT Fellow

e. Publications (110 papers, 5 book chapters, 14,401 citations, 44 h-index, 89 i10-index)

111. **Barrangou R**, Ousterout DG. (2017) Repurposing CRISPR-Cas systems as DNA-based smart antimicrobials. *Cell & Gene Therapy Insights*. 3:63-72 doi:10.18609/cg .2017.008

110. Selle K, Goh YJ, Johnson BR, O'Flaherty S, Andersen JM, **Barrangou R**, Klaenhammer TR. (2017) Deletion of Lipoteichoic Acid Synthase Impacts Expression of Genes Encoding Cell Surface Proteins in *Lactobacillus acidophilus*. *Front Microbiol*. 8:553. doi: 10.3389/fmicb.2017.00553.

109. **Barrangou R**, Gersbach CA. (2017) Expanding the CRISPR Toolbox: Targeting RNA with Cas13b. *Mol Cell*. 65:582-584. doi: 10.1016/j.molcel.2017.02.002

108. Stout E, Klaenhammer T, **Barrangou R**. (2017) CRISPR-Cas Technologies and Applications in Food Bacteria. *Annu Rev Food Sci Technol*. 8:413-437. doi: 10.1146/annurev-food-072816-024723.

107. Morovic W, Hibberd AA, Zabel B, **Barrangou R**, Stahl B. (2016) Genotyping by PCR and High-Throughput Sequencing of Commercial Probiotic Products Reveals Composition Biases. *Front. Microbiol*. dx.doi.org/10.3389/fmicb.2016.01747

106. **Barrangou R**, Doudna JA. (2016) Applications of CRISPR technologies in research and beyond. *Nature Biotechnology* 34:933-941 doi:10.1038/nbt.3659

105. Andersen JM, Shoup M, Robinson C, Britton R, Olsen KEP, **Barrangou R**. (2016) CRISPR diversity and microevolution in *Clostridium difficile*. *Genome Biology and Evolution*. doi: 10.1093/gbe/evw203

104. Briner AE, **Barrangou R**. (2016) Guide RNAs: A Glimpse at the Sequences that Drive CRISPR–Cas Systems. *CRISPR-Cas a laboratory manual*. CSHL Protocols. 17-23

103. Briner AE, Henriksen ED, **Barrangou R**. (2016) Prediction and validation of native and engineered Cas9 guide sequences. *CRISPR-Cas a laboratory manual*. CSHL Protocols. 24-30

102. Brandt K, **Barrangou R**. (2016) Phylogenetic Analysis of the *Bifidobacterium* Genus Using Glycolysis Enzyme Sequences. *Front Microbiol*. 7:657. doi: 10.3389/fmicb.2016.00657.

101. Leenay RT, Maksimchuk KR, Slotkowski RA, Agrawal RN, Gomaa AA, Briner AE, **Barrangou R**, Beisel CL. (2016) Identifying and Visualizing Functional PAM Diversity across CRISPR-Cas Systems. *Mol Cell*. 62:137-47. doi: 10.1016/j.molcel.2016.02.031
100. Briner AE, **Barrangou R**. (2016) Deciphering and shaping bacterial diversity through CRISPR. *Current Op Microbiol*. 31:101-108. doi: 10.1016/j.mib.2016.03.006
99. Sun CL, Thomas BC, **Barrangou R**, Banfield JF. (2016) Metagenomic reconstructions of bacterial CRISPR loci constrain population histories. *ISME J* 10:858-70. doi: 10.1038/ismej.2015.162.
98. Hymes J, Johnson B, **Barrangou R**, Klaenhammer TR. (2016) Functional analysis of an S-layer associated fibronectin binding protein in *Lactobacillus acidophilus*. *App Environ Microbiol pii: AEM.00024-16*
97. **Barrangou R**, Dudley EG. (2016) CRISPR-based typing and next-generation tracking technologies. *Ann Rev Food Sci Technol* 7:395-411. doi: 10.1146/annurev-food-022814-015729
96. **Barrangou R**, van Pijkeren JP. (2015) Exploiting CRISPR-Cas immune systems for genome editing in bacteria. *Curr Op Biotechnol* 37:61-68. doi: 10.1016/j.copbio.2015.10.003
95. **Barrangou R**. (2015) Diversity of CRISPR-Cas immune systems and molecular machines. *Genome Biol* 16:247. doi: 10.1186/s13059-015-0816-9
94. Johnson BR, Hymes J, Sanozky-Dawes R, Henriksen EE, **Barrangou R**, Klaenhammer TR. (2015) Exoproteome analysis of S-layer forming lactobacilli reveals conserved S-layer associated proteins (SLAPs). *App Environ Microbiol* 82:134-45. doi: 10.1128/AEM.01968-15
93. Selle KM, **Barrangou R**. (2015) CRISPR-based technologies and the future of food science. *J Food Sci* 80:R2367-72. doi: 10.1111/1750-3841.13094
92. Sun Z, Harris HMB, McCann A, Yang X, Argimon S, Zhang W, Guo C, Jeffery IB, Cooney JC, Kagawa TF, Liu W, Song Y, Salvetti E, Wrobel A, Rasinkangas P, Parkhill J, Rea MC, O'Sullivan O, Ritari J, Douillard FP, Ross RP, Yang R, Briner A, Felis G, de Vos WM, **Barrangou R**, Klaenhammer TR, Caufield PW, Cui Y, Zhang H, O'Toole PW. (2015) Expanding the biotechnology potential of lactobacilli through comparative genomics. *Nature Comm* 6:8322. doi: 10.1038/ncomms9322.
91. Makarova KS, Wolf YI, Alkhnbashi O, Costa F, Shah S, Saunders SJ, **Barrangou R**, Brouns SJJ, Charpentier E, Haft DH, Horvath P, Moineau S, Mojica FJM, Terns RM, Terns MA, White MF, Yakunin AF, Garrett RA, van der Oost J, Backofen R, Koonin EV. (2015) An updated evolutionary classification scheme for CRISPR-Cas systems. *Nature Rev Microbiol* 13:722-36. doi:10.1038/nrmicro3569
90. Sanozky-Dawes R, Selle K, O'Flaherty SO, Klaenhammer TR, **Barrangou R**. (2015) Occurrence and activity of a type II CRISPR-Cas system in *Lactobacillus gasseri*. *Microbiology*. 161:1752-61 doi: 10.1099/mic.0.000129
89. Briner AE, Lugli GA, Milani C, Duranti S, Turrone F, Gueimonde M, Margolles A, van

- Sinderen D, Ventura M, **Barrangou R** (2015) Occurrence and Diversity of CRISPR-Cas Systems in the Genus *Bifidobacterium*. PLoS One 10:e0133661
88. Sontheimer EJ, **Barrangou R** (2015) The Bacterial Origins of the CRISPR Genome-Editing Revolution. Hum Gene Ther 26:413-24
87. Selle K, Klaenhammer TR, **Barrangou R** (2015) CRISPR-based screening of genomic island excision events in bacteria. Proc Natl Acad Sci U S A 112:8076-81
86. Dupuis MÈ, **Barrangou R**, Moineau S (2015) Procedures for Generating CRISPR Mutants with Novel Spacers Acquired from Viruses or Plasmids. Methods Mol Biol. 1311:195-222
85. Paez-Espino D, Sharon I, Morovic W, Stahl B, Thomas BC, **Barrangou R**, Banfield JF (2015) CRISPR immunity drives rapid phage genome evolution in *Streptococcus thermophilus*. MBio. 6:e00262-15
84. Kyung KH, Medina Pradas E, Kim SG, Lee YJ, Kim KH, Choi JJ, Cho JH, Chung CH, **Barrangou R**, Breidt F (2015) Microbial ecology of watery kimchi. J Food Sci. 80:M1031-8
83. **Barrangou R**, Birmingham A, Wiemann S, Beijersbergen RL, Hornung V, Smith A (2015) Advances in CRISPR-Cas9 genome engineering: lessons learned from RNA interference. Nucleic Acids Res. 43:3407-19
82. Selle K, **Barrangou R** (2015) Harnessing CRISPR-Cas systems for bacterial genome editing. Trends Microbiol. 23:225-32
81. **Barrangou R** (2015) The roles of CRISPR-Cas systems in adaptive immunity and beyond. Curr Opin Immunol. 32:36-41
80. **Barrangou R**, van der Oost J. (2015) Bacteriophage exclusion, a new defense system. EMBO J. 34:134-135
79. **Barrangou R**, May AP (2015) Unraveling the potential of CRISPR-Cas9 for gene therapy. Expert Opin Biol Ther 15:311-4
78. Shariat N, Timme RE, Pettengill JB, **Barrangou R**, Dudley E. (2015) Characterization and Evolution of *Salmonella* CRISPR-Cas Systems. Microbiology 161:374-386.
77. **Barrangou R**, Horvath P. (2014) Functions and applications of RNA-guided CRISPR-Cas immune systems. Enc Mol Cell Biol Mol Med DOI: 10.1002/3527600906.mcb.20130001
76. Beisel CL, Gomaa AA, **Barrangou R**. (2014) A CRISPR design for next-generation antimicrobials. Genome Biol 15:516
75. Briner AE, Donohoue PD, Gomaa AA, Selle K, Slorach EM, Nye CH, Haurwitz RE, Beisel CL, May AP, **Barrangou R**. (2014) Guide RNA functional modules direct Cas9 activity and orthogonality. Mol Cell 56:333-9
74. Milani C, Lugli GA, Duranti S, Turrone F, Bottacini F, Mangifesta M, Sanchez B, Viappiani A, Mancabelli L, Taminiau B, Delcenserie V, **Barrangou R**, Margolles A, van Sinderen D,

Ventura M. (2014) Genomic encyclopedia of type strains of the genus *Bifidobacterium*. Appl Environ Microbiol 80:6290-302

73. Wehnes CA, Rehberger TG, **Barrangou R**, Smith AH. (2014) Determination of *Salmonella* clustered regularly interspaced short palindromic repeats (CRISPR) diversity on dairy farms in Wisconsin and Minnesota. J Dairy Sci 97:6370-7

72. **Barrangou R**, Klaenhammer TR. (2014) Bacteria get vaccinated. Nature 513:175-6

71. **Barrangou R**. (2014) Cas9 targeting and the CRISPR revolution. Science 344:707-8

70. Carte J, Christopher RT, Smith JT, Olson S, **Barrangou R**, Moineau S, Glover CV 3rd, Graveley BR, Terns RM, Terns MP. (2014) The three major types of CRISPR-Cas systems function independently in CRISPR RNA biogenesis in *Streptococcus thermophilus*. Mol Microbiol 93:98-112

69. **Barrangou R**, Marraffini LA. (2014) CRISPR-Cas systems: Prokaryotes upgrade to adaptive immunity. Mol Cell 54:234-44

68. Pettengill JB, Timme RE, **Barrangou R**, Toro M, Allard MW, Strain E, Musser SM, Brown EW. (2014) The evolutionary history and diagnostic utility of the CRISPR-Cas system within *Salmonella enterica* ssp. enterica. PeerJ 2:e340

67. Gomaa AA, Klumpe HE, Luo ML, Selle K, **Barrangou R**, Beisel CL. (2014) Programmable removal of bacterial strains by use of genome-targeting CRISPR-Cas systems. MBio 5:e00928-13

66. Toro M, Cao G, Ju W, Allard M, **Barrangou R**, Zhao S, Brown E, Meng J. (2014) Association of clustered regularly interspaced short palindromic repeat (CRISPR) elements with specific serotypes and virulence potential of shiga toxin-producing *Escherichia coli*. Appl Environ Microbiol 80:1411-20

65. Briner AE, **Barrangou R**. (2014) *Lactobacillus buchneri* genotyping on the basis of clustered regularly interspaced short palindromic repeat (CRISPR) locus diversity. Appl Environ Microbiol. 80:994-1001

64. Abou Hachem M, Møller MS, Andersen JM, Fredslund A, Majumder A, Nakai H, Lo Leggio L, Goh YJ, **Barrangou R**, Klaenhammer TR, Svensson B. (2013) A snapshot into the metabolism of isomalto-oligosaccharides in probiotic bacteria. J Appl Glycosci 60:95-100

63. Abou Hachem M, Andersen JM, **Barrangou R**, Møller MS, Fredslund F, Majumder A, Ejby M, Lahtinen SJ, Jacobsen S, Lo Leggio L, Goh YJ, Klaenhammer TR, Svensson B. (2013) Recent insight into oligosaccharide uptake and metabolism in probiotic bacteria. Biocat Biotransform 31:226-235

62. **Barrangou R**, Coûté-Monvoisin AC, Stahl B, Chavichvily I, Damange F, Romero DA, Boyaval P, Fremaux C, Horvath P. (2013) Genomic impact of CRISPR immunization against bacteriophages. Biochem Soc Trans 41:1383-91.

61. Shariat N, Sandt CH, DiMarzio MJ, **Barrangou R**, Dudley E.G. (2013) CRISPR-MVLST

subtyping of *Salmonella enterica* subsp. *enterica* serovars Typhimurium and Heidelberg and application in identifying outbreak isolates. *BMC Microbiol* 13:254.

60. Timme RE, Pettengill JB, Allard MW, Strain E, **Barrangou R**, Wehnes C, Van Kessel JS, Karns JS, Musser SM, Brown EW. (2013) Phylogenetic diversity of the enteric pathogen *Salmonella enterica* subsp. *enterica* inferred from genome-wide reference-free SNP characters. *Genome Biol Evol* 5:2109-23.

59. Loquasto JR, **Barrangou R**, Dudley EG, Stahl B, Chen C, Roberts RF. (2013) *Bifidobacterium animalis* subsp. *lactis* ATCC 27673 is a genomically unique strain within this conserved subspecies. *Appl Environ Microbiol* 79:6903-10

58. Yin S, Jensen MA, Bai J, Debroy C, **Barrangou R**, Dudley EG. (2013) The Evolutionary Divergence of Shiga Toxin-Producing *Escherichia coli* Is Reflected in Clustered Regularly Interspaced Short Palindromic Repeat (CRISPR) Spacer Composition. *Appl Environ Microbiol* 79:5710-20

57. Dimarzio M, Shariat N, Kariyawasam S, **Barrangou R**, Dudley EG. (2013) Antibiotic resistance in *Salmonella* Typhimurium associates with CRISPR sequence type. *Antimicrob Agents Chemother* 9:4282-9

56. Shariat N, Kirchner MK, Sandt CH, Trees E, **Barrangou R**, Dudley EG. (2013) Subtyping of *Salmonella enterica* serovar Newport outbreak isolates by CRISPR-MVLST and determination of the relationship between CRISPR-MVLST and PFGE results. *J Clin Microbiol* 51:2328-36

55. Stahl B, **Barrangou R**. (2013) Complete Genome Sequence of Probiotic Strain *Lactobacillus acidophilus* La-14. *Genome Announc* 1:e00376-13

54. Andersen JM, **Barrangou R**, Abou Hachem M, Lahtinen SJ, Goh YJ, Svensson B, Klaenhammer TR. (2013) Transcriptional analysis of oligosaccharide utilization by *Bifidobacterium lactis* BI-04. *BMC Genomics* 14:312

53. Karvelis T, Gasiunas G, Miksys A, **Barrangou R**, Horvath P, Siksnys V. (2013) crRNA and tracrRNA guide Cas9-mediated DNA interference in *Streptococcus thermophilus*. *RNA Biol* 10:841-51

52. Horvath P, **Barrangou R**. (2013) RNA-guided genome editing à la carte. *Cell Res* 23:733-4.

51. **Barrangou R**. (2013) CRISPR-Cas systems and RNA-guided interference. *Wiley Interdiscip Rev RNA* 4:267-78

50. Shariat N, DiMarzio MJ, Yin S, Dettinger L, Sandt CH, Lute JR, **Barrangou R**, Dudley EG. (2013) The combination of CRISPR-MVLST and PFGE provides increased discriminatory power for differentiating human clinical isolates of *Salmonella enterica* subsp. *enterica* serovar Enteritidis. *Food Microbiol* 34:164-73

49. Levin BR, Moineau S, Bushman M, **Barrangou R** (2013) The Population and Evolutionary Dynamics of Phage and Bacteria with CRISPR-Mediated Immunity. *PLoS Genet* 9:e1003312

48. Paez-Espino D, Morovic W, Sun CL, Thomas BC, Ueda K, Stahl B, **Barrangou R**, Banfield

- JF. (2013) Strong bias in the bacterial CRISPR elements that confer immunity to phage. *Nat Commun* 4:1430
47. Sinkunas T, Gasiunas G, Waghmare SP, Dickman MJ, **Barrangou R**, Horvath P, Siksnys V. (2013) In vitro reconstitution of Cascade-mediated CRISPR immunity in *Streptococcus thermophilus*. *EMBO J* 32:385-94
46. Sun CL, **Barrangou R**, Thomas BC, Horvath P, Fremaux C, Banfield JF. (2013) Phage mutations in response to CRISPR diversification in a bacterial population. *Env Microbiol* 15:463-70
45. Gasiunas G, **Barrangou R**, Horvath P, Siksnys V. (2012) Cas9-crRNA ribonucleoprotein complex mediates specific DNA cleavage for adaptive immunity in bacteria. *Proc Natl Acad Sci U S A* 109:E2579-86
44. **Barrangou R**, Horvath P. (2012) CRISPR: New Horizons in Phage Resistance and Strain Identification. *Annu Rev Food Sci Technol* 3:143-62
43. Weinberger AD, Sun CL, Pluciński MM, Deneff VJ, Thomas BC, Horvath P, **Barrangou R**, Gilmore MS, Getz WM, Banfield JF. (2012) Persisting Viral Sequences Shape Microbial CRISPR-based Immunity. *PLoS Comput Biol* 8:e1002475.
42. Young JC, Dill BD, Pan C, Hettich RL, Banfield JF, Shah M, Fremaux C, Horvath P, **Barrangou R**, Verberkmoes NC. (2012) Phage-Induced Expression of CRISPR-Associated Proteins Is Revealed by Shotgun Proteomics in *Streptococcus thermophilus*. *PLoS One* 7:e38077
41. **Barrangou R**. (2012) RNA-mediated programmable DNA cleavage. *Nat Biotechnol* 30:836-8.
40. Stahl B, **Barrangou R**. (2012) Complete genome sequences of probiotic strains *Bifidobacterium animalis* subsp. *lactis* B420 and Bi-07. *J Bacteriol* 194:4131-2
39. Broadbent JR, Neeno-Eckwall EC, Stahl B, Tandee K, Cai H, Morovic W, Horvath P, Heidenreich J, Perna NT, **Barrangou R**, Steele JL. (2012) Analysis of the *Lactobacillus casei* supragenome and its influence in species evolution and lifestyle adaptation. *BMC Genomics* 5:533.
38. Andersen JM, **Barrangou R**, Hachem MA, Lahtinen SJ, Goh YJ, Svensson B, Klaenhammer TR. (2012) Transcriptional analysis of probiotic uptake and catabolism by *Lactobacillus acidophilus* NCFM. *PLoS One* 7:e44409.
37. Abou Hachem M, Fredslund F, Andersen JM, Jønsgaard Larsen R, Majumder A, Ejby M, Van Zanten G, Lahtinen SJ, **Barrangou R**, Klaenhammer T, Jacobsen S, Coutinho PM, Lo Leggio L, Svensson B. (2012) Raffinose family oligosaccharide utilisation by probiotic bacteria: insight into substrate recognition, molecular architecture and diversity of GH36 alpha-galactosidases. *Biocat Biotransform* 30: 316-325
36. Makarova KS, Haft DH, **Barrangou R**, Brouns SJ, Charpentier E, Horvath P, Moineau S, Mojica FJ, Wolf YI, Yakunin AF, van der Oost J, Koonin EV. (2011) Evolution and classification of the CRISPR-Cas systems. *Nat Rev Microbiol* 9:467-77.

35. Bhaya D, Davison M, **Barrangou R**. (2011) CRISPR-Cas systems in bacteria and archaea: versatile small RNAs for adaptive defense and regulation. *Annu Rev Genet* 45:273-97.
34. Sapranaukas R, Gasiunas G, Fremaux C, **Barrangou R**, Horvath P, Siksnys V. (2011) The *Streptococcus thermophilus* CRISPR/Cas system provides immunity in *Escherichia coli*. *Nucleic Acids Res* 39:9275-82
33. Sinkunas T, Gasiunas G, Fremaux C, **Barrangou R**, Horvath P, Siksnys V. (2011) Cas3 is a single-stranded DNA nuclease and ATP-dependent helicase in the CRISPR/Cas immune system. *EMBO J* 30:1335-42
32. Liu F, **Barrangou R**, Gerner-Smidt P, Ribot EM, Knabel SJ, Dudley EG. (2011) Novel virulence gene and clustered regularly interspaced short palindromic repeat (CRISPR) multilocus sequence typing scheme for subtyping of the major serovars of *Salmonella enterica* subsp. *enterica*. *Appl Environ Microbiol* 77:1946-56
31. Liu F, Kariyawasam S, Jayarao BM, **Barrangou R**, Gerner-Smidt P, Ribot EM, Knabel SJ, Dudley EG. (2011) Subtyping *Salmonella* serovar Enteritidis isolates from different sources using sequence typing based on virulence genes and CRISPRs. *Appl Environ Microbiol* 77:4520-6
30. Duong T, Miller MJ, **Barrangou R**, Azcarate-Peril MA, Klaenhammer TR. (2011) Construction of vectors for inducible and constitutive gene expression in *Lactobacillus*. *Microb Biotechnol* 4:357-67
29. Andersen JM, **Barrangou R**, Abou Hachem M, Lahtinen S, Goh YJ, Svensson B, Klaenhammer TR. (2011) Transcriptional and functional analysis of galactooligosaccharide uptake by *lacS* in *Lactobacillus acidophilus*. *Proc Natl Acad Sci USA* 108:17785-90
28. Loquasto JR, **Barrangou R**, Dudley EG, Roberts RF. (2011) The complete genome sequence of *Bifidobacterium animalis* subspecies *animalis* ATCC 25527(T) and comparative analysis of growth in milk with *B. animalis* subspecies *lactis* DSM 10140(T). *J Dairy Sci* 94:5864-70.
27. Horvath P, **Barrangou R**. (2010) CRISPR/Cas, the immune system of bacteria and archaea. *Science* 327:167-170
26. Garneau JE, Dupuis MÈ, Villion M, Romero DA, **Barrangou R**, Boyaval P, Fremaux C, Horvath P, Magadán AH, Moineau S. (2010) The CRISPR/Cas bacterial immune system cleaves bacteriophage and plasmid DNA. *Nature* 468:67-71
25. Putaala H, **Barrangou R**, Leyer GJ, Ouwehand AC, Hansen EB, Romero DA, Rautonen N. (2010) Analysis of the human intestinal epithelial cell transcriptional response to *Lactobacillus acidophilus*, *Lactobacillus salivarius*, *Bifidobacterium lactis* and *Escherichia coli*. *Beneficial Microbes* 1:283-295
24. Horvath P, Coûté-Monvoisin AC, Romero DA, Boyaval P, Fremaux C, **Barrangou R**. (2009) Comparative analysis of CRISPR loci in lactic acid bacteria genomes. *Int J Food Microbiol* 131:62-70

23. **Barrangou R**, Briczinski EP, Traeger LL, Loquasto JR, Richards M, Horvath P, Coûté-Monvoisin AC, Leyer G, Rendulic S, Steele JL, Broadbent JR, Oberg T, Dudley EG, Schuster S, Romero DA, Roberts RF. (2009) Comparison of the complete genome sequences of *Bifidobacterium animalis* subsp. *lactis* DSM 10140 and BI-04. *J Bacteriol* 191:4144-4151
22. Briczinski EP, Loquasto JR, **Barrangou R**, Dudley EG, Roberts AM, Roberts RF. (2009) Strain-specific genotyping of *Bifidobacterium animalis* subsp. *lactis* by using single-nucleotide polymorphisms, insertions, and deletions. *Appl Environ Microbiol* 75:7501-7508
21. Ventura M, Turrone F, Lima-Mendez G, Foroni E, Zomer A, Duranti S, Giubellini V, Bottacini F, Horvath P, **Barrangou R**, Sela DA, Mills DA, van Sinderen D. (2009) Comparative analyses of prophage-like elements present in bifidobacterial genomes. *Appl Environ Microbiol* 75:6929-6936
20. **Barrangou R**, Horvath P. (2009) The CRISPR system protects microbes against phages, plasmids. *Microbe* 4:224-230
19. Deveau H, **Barrangou R**, Garneau JE, Labonté J, Fremaux C, Boyaval P, Romero DA, Horvath P, Moineau S. (2008) Phage response to CRISPR-encoded resistance in *Streptococcus thermophilus*. *J Bacteriol* 190:1390-1400
18. Horvath P, Romero DA, Coûté-Monvoisin AC, Richards M, Deveau H, Moineau S, Boyaval P, Fremaux C, **Barrangou R**. (2008) Diversity, activity and evolution of CRISPR loci in *Streptococcus thermophilus*. *J Bacteriol* 190:1401-1412
17. Azcarate-Peril MA, Altermann E, Goh YJ, Tallon R, Sanozky-Dawes RB, Pfeiler EA, O'Flaherty S, Buck BL, Dobson A, Duong T, Miller MJ, **Barrangou R**, Klaenhammer TR. (2008) Analysis of the genome sequence of *Lactobacillus gasseri* ATCC33323 reveals the molecular basis of an autochthonous intestinal organism. *App Environ Microbiol* 74:4610-4625
16. Klaenhammer TR, Altermann E, Pfeiler E, Buck BL, Goh YJ, O'Flaherty S, **Barrangou R**, Duong T. (2008) Functional genomics of probiotic lactobacilli. *J Clin Gastroenterol* 42:S160-162.
15. **Barrangou R**, Fremaux C, Deveau H, Richards M, Boyaval P, Moineau S, Romero DA, Horvath P. (2007) CRISPR provides acquired resistance against viruses in prokaryotes. *Science* 315:1709-12
14. Klaenhammer TR, Azcarate-Peril MA, Altermann E, **Barrangou R**. (2007) Influence of the dairy environment on gene expression and substrate utilization in lactic acid bacteria. *J Nutr* 137:748S-50S
13. Yoon SS, **Barrangou R**, Breidt Jr F, Fleming HP. (2007) Detection and characterization of a lytic *Pediococcus* bacteriophage from fermenting cucumber brine. *J Microbiol Biotechnol* 17:262-270
12. Makarova K, Slesarev A, Wolf Y, Sorokin A, Mirkin B, Koonin E, Pavlov A, Pavlova N, Karamychev V, Polouchine N, Shakhova V, Grigoriev I, Lou Y, Rohksar D, Lucas S, Huang K, Goodstein DM, Hawkins T, Plengvidhya V, Welker D, Hughes J, Goh Y, Benson A, Baldwin K, Lee JH, Díaz-Muñiz I, Dosti B, Smeianov V, Wechter W, Barabote R, Lorca G, Altermann E,

Barrangou R, Ganesan B, Xie Y, Rawsthorne H, Tamir D, Parker C, Breidt F, Broadbent J, Hutkins R, O'Sullivan D, Steele J, Unlu G, Saier M, Klaenhammer T, Richardson P, Kozyavkin S, Weimer B, Mills D. (2006) Comparative genomics of the lactic acid bacteria. *Proc Natl Acad Sci USA* 103:15611-15616

11. **Barrangou R**, Azcarate-Peril MA, Duong T, Conners SB, Kelly RM, Klaenhammer TR. (2006) Global analysis of carbohydrate utilization by *Lactobacillus acidophilus* using cDNA microarrays. *Proc Natl Acad Sci USA* 103:3816-3821

10. Ventura M, Canchaya C, Bernini V, Altermann E, **Barrangou R**, McGrath S, Claesson MJ, Li Y, Leahy S, Walker CD, Zink R, Neviani E, Steele J, Broadbent J, Klaenhammer TR, Fitzgerald GF, O'toole PW, van Sinderen D. (2006) Comparative genomics and transcriptional analysis of prophages identified in the genomes of *Lactobacillus gasseri*, *Lactobacillus salivarius* and *Lactobacillus casei*. *Appl Environ Microbiol* 72:3130-3146

9. Duong T, **Barrangou R**, Russell WM, Klaenhammer TR. (2006) Characterization of the *tre* locus and analysis of trehalose cryoprotection in *Lactobacillus acidophilus* NCFM. *Appl Environ Microbiol* 72:1218-1225

8. Altermann E, Russell WM, Azcarate-Peril MA, **Barrangou R**, Buck BL, McAuliffe O, Souther N, Dobson A, Duong T, Callanan M, Lick S, Hamrick A, Cano R, Klaenhammer TR. (2005) Complete genome sequence of the probiotic lactic acid bacterium *Lactobacillus acidophilus* NCFM. *Proc Natl Acad Sci USA* 102:3887-4216

7. Klaenhammer TR, **Barrangou R**, Buck BL, Azcarate-Peril MA, Altermann E. (2005) Genomic features of lactic acid bacteria effecting bioprocessing and health. *FEMS Microbiol Rev* 29:393-409

6. Klaenhammer TR, Azcarate-Peril MA, **Barrangou R**, Duong T, Altermann E. (2005) Genomic perspectives on probiotic lactic acid bacteria. *Biosc Microflora* 24:31-33

5. Pridmore RD, Berger B, Desiere F, Vilanova D, Barretto C, Pittet AC, Zwahlen MC, Rouvet M, Altermann E, **Barrangou R**, Mollet B, Mercenier A, Klaenhammer T, Arigoni F, Schell MA. (2004) The genome sequence of the probiotic intestinal bacterium *Lactobacillus johnsonii* NCC533. *Proc Natl Acad Sci USA* 101:2512-2517

4. **Barrangou R**, Altermann E, Hutkins R, Cano R, Klaenhammer TR. (2003) Functional and comparative genomic analyses of an operon involved in fructooligosaccharide utilization by *Lactobacillus acidophilus*. *Proc Natl Acad Sci USA* 100:8957-8962

3. **Barrangou R**, Yoon SS, Breidt Jr F Jr, Fleming HP, Klaenhammer TR. (2002) Characterization of six *Leuconostoc fallax* bacteriophages isolated from an industrial sauerkraut fermentation. *Appl Environ Microbiol* 68:5452-5458

2. **Barrangou R**, Yoon SS, Breidt F Jr, Fleming HP, Klaenhammer TR. (2002) Identification and characterization of *Leuconostoc fallax* strains isolated from an industrial sauerkraut fermentation. *Appl Environ Microbiol* 2877-2884

1. Yoon SS, **Barrangou R**, Breidt Jr F, Klaenhammer TR, Fleming HP. (2002) Isolation and characterization of bacteriophages from fermenting sauerkraut. *Appl Environ Microbiol* 68:973-

Books and book chapters:

5. **Barrangou R**, van der Oost J. eds. (2012) CRISPR-Cas systems: RNA-mediated adaptive immunity in bacteria and archaea. Springer Science & Business Media
4. Horvath P, Gasiunas G, Siksnys V, **Barrangou R**. (2012) Applications of the versatile CRISPR-Cas systems. CRISPR-Cas systems: RNA-mediated adaptive immunity in bacteria and archaea. Springer Science & Business Media 267-286
3. **Barrangou R**, Lahtinen SJ, Ibrahim F, Ouwehand AC. (2012) Genus lactobacillus. Lactic acid bacteria. Microbiological and functional aspects, 73
2. **Barrangou R**, Horvath P. (2011) Lactic Acid Bacteria Defenses Against Phages. Stress Responses of Lactic Acid Bacteria. Springer US, 459-478
1. **Barrangou R**, Horvath P. (2010) Protection against foreign DNA. Bacterial stress responses. American Society for Microbiology Press, 333-348

f. Collaborators & Grants*Collaborators*

Todd Klaenhammer, NC State: functional genomics of probiotic lactobacilli
 Ed Dudley, Penn State: molecular typing of *Salmonella* and *E coli* using CRISPR Loci
 Bruce Levin, Emory : modeling phage-host population dynamics using CRISPR systems
 Marco Ventura, University of Parma: occurrence and activity of CRISPR in bifidobacteria
 JP van Pijkeren, University of Wisconsin-Madison: CRISPR-based antimicrobials
 Casery Theriot, NC State University: probiotics & CRISPR-based solutions against *C. difficile*
 Dave Ousterout, Locus Biosciences: CRISPR-based antimicrobials against infectious disease
 Joshua Young, DuPont Pioneer: use of Cas9 nucleases for plant genome editing

Current Research Support

NIH (R21 co-PI, PINS 62045, 2015-2017) *A biotherapeutic CRISPR-delivery platform to eradicate Clostridium difficile.*
 NSF BBBE (co-PI). (CBET-1403135, 2014-2017) *Engineering highly specific and orthogonal CRISPR-Cas systems.*
 DuPont Pioneer (PI, PINS 63352, 2015-2017) *GRAS CRISPR-Cas9 systems for genome editing in plants*
 USDA-NIFA (co-PI, PINS 61227), (2015-2016) *Development of Methods for Knockout Chickens: CRISPR-Cas Genome Editing To Understand Foodborne Pathogen-Host Interactions In Poultry*

Past Research Support

FNU (Denmark Research council) (co-PI). (2014-2016). *Occurrence and diversity of CRISPR-Cas systems in clostridia.*
 Danish Council for Independent Research (PI, PINS 63956) *Prebiotic utilization by probiotic bacteria.*
 North Carolina State University Chancellor Innovation Fund (PI, PINS 56415). (2014-2015). *Novel CRISPR Systems for Genome Editing.*

North Carolina Biotechnology Center (PI, PINS 57198). (#558507, 2014-2015). *Novel CRISPR-Cas9 systems for enhanced genome editing.*

North Carolina State University CALS enhancement grant (co-PI, PINS 55185). (2013-2014)
Enhancer Excision based on CRISPR technology: a tool for deciphering gene regulation.

g. Patents

- **R. Barrangou et al.** “Methods and compositions for probiotic delivery of CRISPR-based antimicrobials” (62/271,114; IDF16066)
- **R. Barrangou et al.** “Methods for screening bacteria, archaea, algae and yeast using CRISPR nucleic acid” (62/168,355; IDF15239)
- **R. Barrangou et al.** “Methods and compositions for genome editing in bacteria using CRISPR-Cas9 systems” (62/180,977; IDF 15242)
- **R. Barrangou et al.** “Compositions for multiple guide RNAs for use with CRISPR-Cas9 technologies” (62/182,895; IDF 15187)
- **R. Barrangou et al.** “Novel Cas9 proteins and guiding features for DNA targeting and genome editing” (62/043,204; 62/043,882; IDF 14230)
- **R. Barrangou et al.** “Methods and compositions for sequences guiding Cas9 targeting” (PCT/US2015/012747; US provisional 61/931,515; 61/986,427; IDF 14110)
- **R. Barrangou et al.** “Compositions and methods related to a Type II CRISPR-Cas system in *Lactobacillus buchneri*” (PCT/US2014/62801; US provisional 61/897,670; IDF 14047)
- **R. Barrangou et al.** Cultures with improved phage resistance. (WO2008108989; US20110002889)
- **R. Barrangou et al.** Tagged microorganisms and methods of tagging. (WO2007136815; US20080124725; US20100104690)
- **R. Barrangou et al.** Use of *cas* genes (US20100093617; US20100011828)
- **R. Barrangou et al.** Bifidobacteria CRISPR sequences (US20110300538)
- **R. Burcelin et al.** Lactic acid bacteria and bifidobacteria for treating endotoxemia (WO20120183516; US20120183516)
- **P. Horvath et al.** Resistance of a cell against a target nucleic acid or a transcription product thereof. (WO2007025097)
- **R.W. Russell et al.** Detection and typing of bacterial strains. (7,919,277; 8,361,725; US 20060199190; US20110300541; US20130158245)
- **R. Barrangou et al.** *Lactobacillus acidophilus* nucleic acids encoding fructo-oligosaccharide utilization compounds and uses thereof. (7,824,894; 7,407,787; US20050123941; US20090005311; US20110008292)
- **R. Barrangou et al.** Compositions comprising promoter sequences and methods of use (7,495,092; US20060166323; US20090155913)
- **T. R. Klaenhammer et al.** *Lactobacillus acidophilus* nucleic acid sequences encoding carbohydrate utilization-related proteins and uses thereof. (7,838,276; 7,459,289; 8,178,337; US20070003668; US20090005311; US20110081707; US20120196325)

h. Select seminars and conference highlights

- Gairdner Foundation symposium, University of Toronto (October 2016)
- Warren Alpert Symposium, Harvard Medical School (October 2016)
- Fifth International CRISPR meeting, Tel Aviv (May 2016)
- Genome editing 4.0, MIT/Broad Institute, Boston (May 2016)

- CMAST seminar series, New Bern (April 2016)
- Fourth International CRISPR meeting, Keynote Speaker, New York City (June 2015)
- *Cell* webinar series (October 2015)
- National Evolutionary Synthesis Center, Durham (May 2015)
- University of Michigan, Ann Arbor (October 2015)
- Duke University, RNA Biology meeting, Durham (October 2015)
- North Carolina Biotechnology Center, Triangle Biotech Research Symposium (April 2015)
- North Carolina Agricultural Biotechnology Summit, Raleigh (November 2014)
- North Carolina Biotechnology Research Symposium, Durham (October 2014)
- Regulatory RNAs symposium, Berkeley (October 2014)
- Plant Biotechnology Conference, Raleigh (July 2014)
- Third International CRISPR meeting, Berlin (June 2014)
- IFTSA, Raleigh (April 2014)
- GEN Webinar (January 2014)
- Second International CRISPR meeting, Keynote address, St Andrews (June 2013)
- 7th workshop on virus evolution, State College (March 2013)
- Gordon Conference on Microbial Population Biology, Proctor Academy (July 2013)
- CRISPR meeting, UC Berkeley, co-host and organizer (July 2012)
- ASM annual meeting, San Francisco (June 2012)
- Molecular Genetics of Phage and Bacteria Meeting, Madison (August 2011)
- CRISPR meeting, Berkeley, co-host and organizer (June 2011)
- First International CRISPR meeting, Keynote Speaker, Wageningen (2010)
- Departmental seminars presented at: University of Arizona, Emory University, University of Georgia, North Carolina State University, the Pennsylvania State University, the University of Illinois at Urbana-Champaign, University of Wisconsin-Madison, Duke University, University of Michigan, University of North-Carolina Chapel Hill.
- Invited CRISPR seminars presented at commercial and industrial stakeholders: DuPont, Caribou Biosciences, Pioneer, AgBiome, Intellia Therapeutics, Dharmacon, GE Healthcare, GSK, Raleigh Science Museum, Syngenta, Syngenta Ventures, Biogemma/Limagrain, Precision Biosciences, STI Ag, Novozymes, BRI, Chr Hansen, Locus Biosciences, AgriMetis, AmpliPhi, BASF.

i. Student advising

Graduated

Briner, Alexandra E	FBNS	MS 'Spring 2015
Daughtry, Katheryne V	FBNS	MS 'Spring 2016
Dekam, Emily Ae-Hui	FBNS	MS 'Summer 2016
Hymes, Jeffrey	FBNS	MS 'Spring 2016
Johnson, Brant R	Micro	PhD 'Spring 2016
Selle, Kurt M	Genomics	PhD 'Spring 2016

In progress, chair or co-chair

Canez, Casie Lynn	Genomics	MS advisor
Briner, Alexandra E	Genomics	PhD advisor
Brandt, Katelyn	Genomics	PhD advisor
Klotz, Courtney E	Genomics	PhD advisor

Graduated, Committee Member

Manuel, Clyde Simmons	FBNS	PhD 'Spring2016
Mahmoud Gomaa, Ahmed	ChemE	PhD 'Summer 2016

In progress, Committee Member

Almand, Erin Ahmo	FBNS	PhD Committee member
Cauley, Sarah M	FBNS	PhD Committee member
Fan, Sicun	FBNS	PhD Committee member
Palatini, Kimberly Marie	FBNS	PhD Committee member
Parsons, Cameron T	FBNS	PhD Committee member
Zeldes, Benjamin	ChemE	PhD Committee member
Luo, Michelle Lynn	ChemE	PhD Committee member

At Penn State University

Zhaoyong, Ba	Food Science	PhD 2015
Shuang, Yin	Food Science	PhD 2014
Joseph Loquasto	Food Science	PhD 2013
Liu, Fenyun	Food Science	MS 2010

j. Instruction

2016 Spring Term

BBS 201-001 (Class 1391) Introduction to Biopharmaceutical Sciences, 22 enrolled
FS 693-001 (Class 3506) MR Supervised Research, 1 enrolled
FS 725-001 (Class 6686) Fermentation Microbiology, 14 enrolled
FS 893-001 DR Supervised Research, 3 enrolled
MB 725-001 Fermentation Microbiology, 3 enrolled

2015 Fall Term

FS 693-001 (Class 4147) MR Supervised Research, 1 enrolled
FS 893-001 (Class 4159) DR Supervised Research, 3 enrolled
MB 695-001 (Class 12154) MR Thesis Research, 1 enrolled

2015 Spring Term

BBS 201-001 (Class 1411) Introduction to Biopharmaceutical Sciences, 15 enrolled
FS 693-001 (Class 3630) MR Supervised Research, 1 enrolled
FS 699-001 (Class 3632) MR Thesis Preparation, 1 enrolled

2014 Fall Term

FS 693-001 (Class 4622) MR Supervised Research, 1 enrolled

2014 Spring Term

BBS 201-001 (class#1532) Introduction to Biopharmaceutical Sciences, 24 enrolled
FS 693-001 (class#4386) MR Supervised Research, 1 enrolled

2013 Fall Term

FS 693-001 (class#5306) MR Supervised Research, 1 enrolled

k. Committees and service

A. FBNS Department

- Food Science Club Advisor and Executive Board Member 2013-2014
- FBNS Preliminary examination, committee member 2013-2014
- FBNS Strategic Planning, committee chair, 2013-2014; 2014-2015
- FBNS Undergraduate Curriculum Committee, member 2015-2016
- FBNS Preliminary examination, committee member 2015-2016
- FBNS Graduate Curriculum Committee, Member 2016-2017

B. CALS

- CALS Big Ideas Committee (2014)
- CALS Efficiency and Innovation Committee (2015)
- CALS Stewart of the Future Committee Chair (2015-2016)
- CALS Plant Sciences Initiative (2016-2017)

C. University

- Microbiome Stewards of the Future co-chair (2016)
- Microbiome cluster hire committee (2015-2017)
- Microbiology interdisciplinary program faculty member
- Biotechnology interdisciplinary program faculty member
- Functional Genomics interdisciplinary program faculty member
- Comparative Medicine Institute faculty member

D. Professional Associations

- ASM General Membership (since 2013)
- IFT General Membership (since 2013)
- ASCS General Membership (since 2015)
- AEM Editorial Board member (since 2015)

E. Peer reviewing

Ad hoc reviewer and referee for Science, Nature, Cell, Nature Biotechnology, Molecular Cell, PLoS Genetics, Nature Communications, Nature Methods, Nature Microbiology, PNAS, Genome Biology, Molecular Biology, EMBO J, Nucleic Acids Research, BMC Genomics, BMC Microbiology, MBio, Journal of Virology, PLoS ONE, Journal of Bacteriology, ISME Journal. A total of 146 manuscripts (29 in 2013, 35 in 2014, 48 in 2015, 44 in 2016) have been reviewed since joining NC State in 2013.