

## Biographical Sketch

**Northen Trent**      **Career Chemist Staff Scientist, Lawrence Berkeley National Laboratory**

### Education and Training:

<u>Institution and Location</u>	<u>Degree/Training</u>	<u>Year</u>	<u>Field of Study</u>
University of California Santa Barbara	B.Sc.	1996	Chemical Engineering
Arizona State University	Ph.D.	2006	Chemistry & Biochemistry
The Scripps Research Institute	n/a	2006-2008	Mass Spectrometry
Lawrence Berkeley National Laboratory	n/a	2008	Mass Spectrometry

### Research and Professional Experience:

#### Professional Experience

2012-Present    Director of array-based assays, Joint Bioenergy Institute, Berkeley Lab  
2012-Present    Member, West Coast Metabolomics Institute  
2012-Present    Nextval, Founder and Scientific Advisory Board member  
2011-Present    Member, Synthetic Biology Institute, UC Berkeley  
2011-Present    Director of Biotechnology, ENIGMA program  
2011-Present    Career Chemist Staff Scientist, Life Sciences Division, Berkeley Lab  
2009-Present    Berkeley Lab Carbon Cycle 2.0 steering committee  
2008-Present    MetaCyc Scientific Advisory Board (SRI International)  
2008-2011      Chemist Research Scientist, Life Sciences Division, Berkeley Lab  
2007-2010      Collaborator and consultant, Sapphire Energy  
2006- 2008      The Scripps Research Institute Center for Mass Spectrometry under Prof. Gary Siuzdak  
2001-2005      Graduate Research/Teaching Assistant under Prof. Neal Woodbury, Arizona State University  
1999-2000      Associate marketing manager, Glad Brands, The Clorox Company  
1997-1999      Scientist and Process Engineer, Brita R&D, The Clorox Company  
1996-1997      Scientist and Process Engineer, Insecticides Department, The Clorox Company

#### Honors

- Presidential Early Career Award in Science and Engineering (Awarded by Obama in 2010)
- SPORE career development award (2009) & (2010)
- Awarded "Innovator of Tomorrow", Arizona State University (ASU)/AzTe (2006)
- Outstanding Research Assistant, Chemistry and Biochemistry Department, ASU (2005)
- Outstanding Teaching Assistant, Chemistry and Biochemistry Department, ASU (2003)
- NSF IGERT fellowship (2001-2005)
- Outstanding Chemical Engineering Student in graduating class (1996)
- Elected into Tau Beta Pi - Engineering Honor Society (since 1995)

#### Most Innovative and Relevant Publications (Limited to 10)

## PUBLICATIONS

1. **Northen, Trent R.**; Woodbury, Neal W. Light-Directed Movement of Polymer Microstructures. *Langmuir* (2005), 21(11), 4949-4953. DOI: 10.1021/la047566b
2. **Northen, Trent R.**; Brune, Daniel C.; Woodbury, Neal W. Synthesis and Characterization of Peptide Grafted Polymer Microstructures. *Biomacromolecules* (2006), 206 (7), 750-754. DOI: 10.1021/bm0506952
3. **Northen, Trent R.**; Yanes, Oscar; Northen, Michael T; Marrinucci, Dena C; Uritboonthai, Winnie; Apon, Junefredo ; Golledge, Stephen L; Nordström, Anders; Sizudak, Gary. Clathrate Nanostructures for Mass Spectrometry. *Nature* (2007) 449, 1033-1036. DOI: 10.1038/nature06195
4. **Northen, Trent R.**; Wu, Hin-Koon, Northen, Michael T; Nordström, Anders; Uritboonthai, Winnie; Turner, Kimberly L., Sizudak, Gary. High Surface Energy of Porous Silicon Drives Desorption of Intact Molecules. *JASMS* (2007) 18 (11), 1945-1949. PMCID: PMC2080661 DOI: 10.1016/j.jasms.2007.08.009
5. Woo H-K., **Northen T.R.**, Yanes O., Siuzdak G. Nanostructure-Initiator Mass Spectrometry (NIMS): A protocol for preparing and applying NIMS surfaces for high sensitivity mass analysis. *Nature Protocols* 3, 1341-1349 (2008). DOI: 10.1038/nprot.2008.110
6. Nordström, Anders; Want Elizabeth; **Northen, Trent** ; Gieschen, Andrew; Fisher, Steven; Siuzdak, Gary. A Multiple Ionization Mass Spectrometry Strategy Used to Reveal the Complexity of Metabolomics. *Analytical Chemistry*, (2008), 80, 421-429. DOI: 10.1021/ac701982e
7. **Northen T.R.** Greving M., Woodbury N.W. Combinatorial Screening of Biomimetic Protein Affinity Materials. *Advanced Materials* (2008) 20, 1-7. Accepted prior to April 7, 2008.
8. **Northen Trent R.**, Lee J-C, Hoang L., Raymond J., Hwang D-R, Yannone S.M., Wong C-H, Siuzdak G. A Nanostructure-Initiator Mass Spectrometry Based Enzyme Activity Assay, *PNAS*, (2008) 105(10), 3678-3683. PMCID: PMC2268803 DOI:10.1073/pnas.0712332105
9. Woo, Hin-Koon; Go, Eden P; Hoang, Linh; Trauger, Sunia A.; Bowen, Benjamin; Siuzdak, Gary; **Northen, Trent R.** Phosphonium Labeling for Increasing Metabolomic Coverage of Neutral Lipids using ESI-MS. *Rapid. Comm. Mass Spec.* (2009) 23(12), 1849-55. PMCID: PMC2268803 DOI: 10.1002/rcm.4076
10. Yanes Oscar; Woo, Hin-Koon; **Northen, Trent**; Oppenheimer, Stacey; Schriver, Leah; Apon, Jon; Estrada, Myra; Potchoiba, Michael; Manchester, Marianne; Siuzdak, Gary. Nanostructure-Initiator Mass Spectrometry (NIMS) Tissue Imaging and Biofluid Analysis. *Analytical Chemistry* (2009), 81 (8), 2969-2975. PMCID: PMC2676195 DOI: 10.1021/ac802576q
11. Baran, Richard; Reindl, Wolfgang; **Northen, Trent**. *Current Op. in Microbiology* (2009), 12, 547-552 COVER.
12. Reindl, Wolfgang; **Northen, Trent**. Rapid Screening of Fatty Acids Using Nanostructure-Initiator Mass Spectrometry. *Analytical Chemistry* (2010), 9, 3751-3755. DOI: 10.1021/ac100159y
13. Bowen, Benjamin P., **Northen, Trent**. Dealing with the unknown: Metabolomics and Metabolite Atlases, *JASMS* (2010). **21(9):1471-1476**. DOI: 10.1016/j.jasms.2010.04.003
14. Jansson, Christer, **Northen, Trent**. Calcifying cyanobacteria-the potential of biomineralization for carbon capture and storage. *curr opin biotechnol* (2010) 2010 Jun;21(3):365-71 DOI: 10.1016/j.copbio.2010.03.017
15. Facciotti M.T., Pang W.L., Lo F-Y., Whitehead K., Koide T., Masumura K., Pan M., Kaur A., Larsen D.J., Reiss D.J., Hoang L., Kalisiak E., Northen T., Trauger S.A., Siuzdak G., Baliga N.S. Large scale physiological readjustment during growth enables rapid, comprehensive and inexpensive system analysis. *BMC Syst Biol* (2010) 4:64 PMCID: PMC2880973 DOI: 10.1186/1752-0509-4-64

16. Lee, Do Yup, Bowen, Benjamin P, **Northern, Trent R.** Mass spectrometry based metabolomics, analysis of metabolite-protein interactions, and imaging. *Biotechniques*, (2010), 49(2): 557-65 (COVER). PMID: PMC2967016 DOI: 10.2144/000113451
17. Baran R, Bowen BP, Bouskill NJ, Brodie EL, Yannone SM, **Northern TR.** Metabolite Identification in *Synechococcus* sp. PCC 7002 Using Untargeted Stable Isotope Assisted Metabolite Profiling. *Analytical Chemistry* (2010) 82(21): 9034–9042 DOI: 10.1021/ac1020112
18. Wilmes, Paul ; Bowen, Benjamin P ; Thomas Brian C; Mueller Ryan S; Deneff Vincent J; VerBerkmoes Nathan C; Hettich Robert L; **Northern Trent R**; and Banfield Jillian F. Metabolome-proteome differentiation coupled to microbial divergence. *mBio* (2010) 1 (5): 1-5. PMID: PMPC2962434
19. Reindl, Wolfgang E; Bowen, Benjamin, P; Balamontis, Michael A; Green, Jeffery, E; **Northern, Trent R.** Multivariate analysis of a 3D mass spectral image for examining tissue heterogeneity. *Integrative Biology* (2011), 3: 460-467. PMID: PMC3495549 DOI: 10.1039/c0ib00091d
20. Bowen, B., Fischer, C., Baran, R., Banfield, J., & **Northern, T.** (2011). Improved genome annotation through untargeted detection of pathway-specific metabolites. *BMC Genomics*, 12(Suppl 1), S6. BioMed Central Ltd. doi:10.1186/1471-2164-12-S1-S6 PMID: PMC32223729 DOI: 10.1186/1471-2164-12-S1-S6
21. Wolfgang Reindl, Kai Deng, John M. Gladden, Gang Cheng, April Wong, Steven W. Singer, Seema Singh, Jinq-Chyi Lee, Chun-Hsu Yao, Terry C. Hazen, Anup K. Singh, Blake A. Simmons, Paul D. Adams and **Trent R. Northern.** Colloid-based multiplexed screening for plant biomass-degrading glycoside hydrolase activities in microbial communities. *Energy and Envir.Sci.* (2011), 4, 2884-2893. DOI: 10.1039/C1EE01112J
22. Baran, Richard, Bowen, Benjamin, Northern, Trent R. Untargeted metabolic footprinting reveals a surprising breadth of metabolite uptake and release by *Synechococcus* sp. PCC 7002. *Molecular BioSystems* 2011, 7, 3200-3206 DOI: 10.1039/c1mb05196b
23. Storm, P; Aits, S; Puthia, MK; Urbano, A; **Northern, T**; Powers, S; Bowen, B; Chao, Y; Reindl, W; Lee, DY; Sullivan, NL; Zhang, L; Trulsson, M; Yang, H; Watson, JD; and Svanborg, C. Conserved features of cancer cells define their sensitivity to HAMLET-induced death; c-Myc and glycolysis. *Oncogene* 30, 4765-4779 DOI:10.1038/onc.2011.196
24. Deng K, George KW, Reindl W, Keasling JD, Adams PA, Lee TS, Singh AK, **Northern TR,** Encoding substrates with mass tags to resolve stereospecific reactions using Nimzyme, *RCM* 2012 Mar 30;26(6):611-5. DOI: 10.1002/rcm.6134.
25. Fischer CR, Wilmes P, Bowen BP, **Northern TR,** Banfield JF. Proton painting Metabolomics Identifies *N*-Methyl *lyso* Phosphatidylethanolamines As Abundant Lipids in Acidophilic Mixed Microbial Communities. *Metabolomics* 2011.
26. Patti G.J, Tautenhahn R., Fonslow B.R., Cho Y., Deutschbauer A., Arkin A., **Northern T.,** Siuzdak G. Meta-Analysis of Global Metabolomics and Proteomics Data to Link Alterations with Phenotype *Spectroscopy (cover article)*, 2011, 26(3), 151-154
27. Greving M, Cheng K, Reindl W, Bowen B, Deng D, Louie K, Nyman M, Cohen J, Singh A, Simmons B, Adams P, Siuzdak G, and **Northern T** Acoustic deposition with NIMS as a high throughput enzyme activity assay, *Anal Bioanal Chemistry* 2012 May;403(3):707-11. Epub 2012 Mar 10. DOI: 10.1007/s00216-012-5908-8

28. Reindl W, Deng K, Cheng X, Singh AK, Simmons B, Adams P, **Northen T** Nanostructure-Initiator Mass Spectrometry (NIMS) for the Analysis of Enzyme Activities, *Curr. Protocols in Chem. Biology*, 2012, 4:123-142 DOI: 10.1002/9780470559277.ch110221
29. Lee DY, Platt V, Bowen B, Louie K, Canaria C, McMurray C, **Northen T**. Resolving brain regions using nanostructure initiator mass spectrometry imaging of phospholipids. *Integrative Biology* 2012, 4 (6), 693 – 699 DOI: 10.1039/c2ib20043k
30. Patti G.J, Tautenhahn R., Fonslow B.R., Cho Y., Deutschbauer A., Arkin A., **Northen T.**, Siuzdak G. Meta-Analysis of Global Metabolomics and Proteomics Data to Link Alterations with Phenotype, *Spectroscopy*, 2012, 26(3), 151-154 [COVER]
31. Lee DY, Bowen B, Louie K, Nguyen, D, Parsa S, Huang Y, Mao JH, **Northen T**. Low-dose ionizing radiation-induced blood plasma metabolic response in a diverse genetic mouse population. *Radiation Research*, 2012 Dec;178(6):551-5. DOI: 10.1667/RR2990.1.
32. Patti G.J, Tautenhahn R., Fonslow B.R., Cho Y., Deutschbauer A., Arkin A., **Northen T.**, Siuzdak G. Meta-Analysis of Global Metabolomics and Proteomics Data to Link Alterations with Phenotype, *Spectroscopy*, 2012, 26(3), 151-154 [COVER]
33. Kamennaya N, Ajo-franklin C, **Northen T**, Jansson C. Biomineralization by Calcifying Cyanobacteria - a Potential Means for Biological Carbon Capture and Storage. *Minerals*. (in press).
34. Baran R, Bowen BP, Price MN, Arkin AP, Deutschbauer AM, **Northen TR**. Metabolic Footprinting of Mutant Libraries To Map Metabolite Utilization to Genotype. *ACS Chemical Biology*. 2013, 8 (1), 189-199. DOI: 10.1021/cb300477w
35. Mosier AC\*, Justice NB\*, Bowen BP, Baran R, Thomas BC, **Northen TR**, Banfield JF. Metabolites associated with adaptation of microorganisms to an acidophilic, metal-rich environment identified by stable isotope enabled metabolomics. 2013 Mar 12;4(2):e00484-12 PMID: PMC3604775 DOI: 10.1128/mBio.00484-12
36. De Rond T, Peralta-Yahya P, Cheng X, **Northen TR**, Keasling JD. Versatile synthesis of probes for high-throughput enzyme activity screening. *Anal Bioanal Chemistry*, 2013 May;405(14):4969-73. DOI: 10.1007/s00216-013-6888-z
37. Ryan P. McAndrew, Joshua Park, Wolfgang Reindl, Gregory D. Friedland, Patrik D'haeseleer, **Trent Northen**, Kenneth L. Sale, Blake A. Simmons, and Paul D. Adam. From soil to structure: a novel dimeric family 3  $\beta$ -glucosidase isolated from compost using metagenomics. *Journal of Biochemistry* 2013 (in Press) DOI: 10.1074/jbc.M113.458356
38. Louie KB, Bowen BP, McAlhany S, Huang Y, Mao JH, Hellerstein M and **Northen TR** Kinetic mass spectrometry imaging for in situ kinetic histochemistry, *Nature Scientific Reports*, 2013 Apr 15;3:1656 PMID: PMC3625901 DOI: 10.1038/srep01656
39. Rajeev L, Nunes da Rocha U, Klitgord N, Luning EG, Fortney J, Axen SP, Shih PM, Bouskill NJ, Bowen BP, Kerfield C, Ferran Garcia-Pichel F, Brodie EL, **Northen TR\***, Mukhopadhyay, A\* Dynamic cyanobacterial response to hydration and dehydration in a desert biological soil crust, *ISME Journal*, 2013 (In Press)

## **PATENTS:**

1. **Northen; Trent R.** (Oakland, CA); Flagler; Robert W. (Pleasanton, CA); Ball; Alan D. (Somerville, MA); Schnakenberg, III; George H. F. (Cambridge, MA). Patent US D435,084. Water Filter (2000)
2. Flagler; Robert W. (Pleasanton, CA); **Northen; Trent R.** (Oakland, CA); Ball; Alan D. (Somerville, MA); Schnakenberg, III; George H. F. (Cambridge, MA). Patent US D437,027 Water filter reservoir (2001)
3. **Northen; Trent R.** (Oakland, CA); Patent WO0223989. Insecticidal Microcrystalline Dry Aerosol Spray (2002).
4. **Northen; Trent, Russell** (Tempe, Az); Woodbury; Neal, Walter. (Tempe, Az); Full Patent Application PCT/US05/15764, U.S. provisional applications 60/569,370, 60/608,774, and 60/623,181 (2004). Microarray of Three-Dimensional Heteropolymer Microstructures and Method Therefor (2005).
5. **Northen; Trent, Russell** (Tempe, Az); Greving; Matthew (Phoenix, Az), Woodbury; Neal, Walter. (Tempe, Az); Full patent application Ser. No. **01231.0039P1** Microstructure and microdomain microarrays, methods and uses therefore (2006). U.S. provisional application Characterization and Synthesis of Three-Dimensional Heteropolymer Microstructure Arrays and Method Therefore (2005)
6. **Northen; Trent, Russell** (San Diego, Ca); Nordström; Anders (La Jolla, Ca); Siuzdak; Gary (La Jolla, Ca); U.S. Patent application 11/852,863. Nanostructure-Initiator Mass Spectrometry (2007).
7. Matthew P. Greving, Neal Woodbury and **Trent Northen**. Porous Acrylate Copolymer Films and Uses Therefor (US 12/018,398) 2008
8. Leclerc, Marion; Bowen, Benjamin P.; **Northen, Trent R.** Provisional Patent Application "NIMS Biometrics" U.S. Patent Application Ser. No: 61/540,794 (2011)
9. **Trent R. Northen**, Wolfgang E. Reindl, Kai Deng, Seema Singh, And Anup K. Singh. Multiplexed screening of enzyme activities using nanostructure-initiator mass spectrometry. US No. 13/363,695
10. Bowen, Benjamin P.; Hellerstein, Marc; Louie, Katherine B.; **Northen, Trent R.** Provisional Patent Application based on technology "NIMS Flux imaging" U.S. Patent Application Ser. No: 61/532,522
11. **Northen, Trent R.**; Deng, Kai; De Rond, Tristan P.; Peralta-Yahya, Pamela P.; Cheng, Xiaoliang; Keasling, Jay D. Rapid Discovery and Optimization of Enzyme Solutions Using Tagged Biomass and Mass Spectrometry. U.S. Patent Application Ser. No: 61/736,409
12. Louie, Katherine B, Bowen, Benjamin P, **Northen, Trent R.** NIMS Lipid Particle Medical Diagnostics". U.S. Patent Application Ser. No: 61/756,401

## **BOOKS:**

**Northen, Trent, R.** The small molecule dimension: mass spectrometry based metabolomics, enzyme assays, and imaging. Handbook of Molecular Microbial Ecology: Metagenomics and Complementary Approaches. Wiley Press. Frans J. de Bruijn Editor

## **TEXTBOOKS:**

**Northen, Trent, R.** Harnessing Microbial Metabolism for Biofuels and Biomaterials. Fundamentals of Materials for Energy and Environmental Sustainability. Cambridge Press. David Ginley & David Cahen Editors.