

# Brian H. Clowers, Ph.D.

Assistant Professor of Chemistry

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## Education

**Post-Doctoral Research Scientist** 2006-2008

Biological Separations and Mass Spectrometry  
Fundamental Science Directorate  
Pacific Northwest National Laboratory  
Advisor: Dr. Richard D. Smith

**Post-Doctoral Research Fellow** 2005-2006

Department of Chemistry  
University of California, Davis  
Advisors: Drs. Carlito B. Lebrilla & Jerry L. Hedrick

**Doctor of Philosophy, Chemistry** 2005

Washington State University, Pullman, WA  
Field of Specialty: Analytical Chemistry  
Dissertation Title: *Separation of Gas Phase Isomers Using Ion Mobility and Mass Spectrometry*  
Advisor: Prof. Herbert H. Hill

**Bachelors of Science, Chemistry (ACS Certified)** 2000

University of Nevada, Reno, NV  
Thesis Title: *Characterization of Diesel Particulate Exposure Levels Experienced by Underground Mine Workers*  
Advisor: Prof. Kent Ervin

## Professional Experience

**Assistant Professor** 2013-Present

Department of Chemistry  
Washington State University

**WSU-PNNL Joint Appointment** 2013-Present

National Security Directorate

**Research Scientist** 2008-2013

Chemical and Biological Sciences  
National Security Directorate  
Pacific Northwest National Laboratory

## **Awards and Recognition**

Emerging Investigator (2017)

- American Society for Mass Spectrometry

Award for Early Career Achievement (2015)

- WSU College of Arts and Sciences

Outstanding Performance Award (2009)

- National Security Directorate, Pacific Northwest National Laboratory

Post-Doctoral Fellowship (2005-2006)

- NIH Fertilization and Early Development Training Grant

NSF Graduate Fellowship (2001-2005)

- NSF IGERT Program

## **Professional Affiliations**

American Society for Mass Spectrometry

International Society for Ion Mobility Spectrometry

American Chemical Society

-Analytical Chemistry Division

## Peer-Reviewed Publications

As of January 17, 2018 the following publications have yielded over 2800 citations with an h-index of 27. Citations with bold numbers represent works completed as a WSU faculty member. (IF = Impact Factor)

Source: <http://scholar.google.com/citations?user=AugbEVsAAAAJ&hl=en> updated 8/1/2017. \*Denotes the start of tenure-track position at WSU

\*Graduate Student

†Undergraduate

‡Post-Doctoral Researcher

63. Davis, A.L.,\* Reinecke, T., ‡ Clowers, B.H. Reducing Ion Mobility Acquisition Time: Basis Pursuit Strategies to IMS-MS Measurements. *Analytical Chemistry*. Submitted Jan. 2018.
62. Morrison, K.A. \* and Clowers, B.H., Contemporary glycomic approaches using ion mobility–mass spectrometry. *Current Opinion in Chemical Biology*, 2018, **42**, 119-129. (IF = 7.9)  
*Role: Clowers contributed significantly to the manuscript including the selection of figures and relevant topics discussed in this invited review article.*

61. Davis, A.L.,\* Clowers, B.H., Leveraging Spectral Sparsity to Realize Enhanced Separation of Gas-Phase Ion Populations Utilizing  $I_1$  Minimization. *International Journal of Mass Spectrometry*. 2017, **20** (3-4), 87-93 (IF = 2.1)  
*Role: Clowers developed the hardware, computer code for the initial pulsing sequences, and provided intellectual guidance in manuscript development.*
60. Garcia, L.,† Saba, C. †, Manocchio, G.,† Anderson, G.A., Davis, E. and Clowers, B.H., An open source ion gate pulser for ion mobility spectrometry. *International Journal for Ion Mobility Spectrometry*, 2017 20(3-4), pp.87-93. (IF = 0.6)  
*Role: The undergraduate group visiting as part of NSF-funded program conducted the experiments with Clowers designing the experiments, providing technical guidance, and manuscript editing.*
59. Kwantwi-Barima, P.\*, Ouyang, Hogan, C. J., Clowers, B. H. Tuning Mobility Separation Factors of Chemical Warfare Agent Degradation Products via Selective Ion-Neutral Clustering. *Analytical Chemistry*, 2017, **89** (22), 12416-12424. *Analytical Chemistry*. (IF = 5.6)  
*Role: Clowers devised the range of experimental variable and conditions to be probed. Additionally, Clowers devised the underlying data processing scripts used in the analysis campaign.*
58. Keelor, J.D., \* Zambrzycki, S.,\* Li, A.,\* Clowers, B.H., and Fernández, F.M. Atmospheric Pressure Drift Tube Ion Mobility-Orbitrap Mass Spectrometry: Initial Performance Characterization. *Analytical Chemistry*. 2017, **89** (21), 11301-11309 2017. (IF = 5.6)  
*Role: Clowers supplied experimental guidance and operational insight into this class of chemical instrumentation.*
57. Davis, A.L.,\* Clowers, B.H., Stabilization of Gas-Phase Uranyl Complexes Enables Rapid Speciation using Electrospray Ionization and Ion Mobility-Mass Spectrometry. *Talanta* 2018, **176**, 140-150. (IF = 3.5)  
*Role: Clowers identified the potential utility of sulfoxides to stabilize the gas-phase complexes of f-elements and provided intensive guidance on manuscript preparation.*

56. Liu, W., Davis, A.L.,\* Siems, W.F., Yin, D., Clowers, B.H. and Hill Jr, H.H., 2017. Ambient pressure inverse ion mobility spectrometry coupled to mass spectrometry. *Analytical Chemistry*, 2017, **89**(5), pp.2800-2806. (IF = 5.6)  
*Role: Clowers devised the initial ion gate pulsing schemes and was primarily responsible for the manuscript revision and figure assembly.*
55. Britch, S. C.,\* Wiley, J. L.,\* Yu, Z., \* Clowers, B. H., Craft, R. M. Cannabidiol- $\Delta^9$ -Tetrahydrocannabinol Interactions on Acute Pain and Locomotor Activity. *Drug and Alcohol Dependence*. 2017, **175**, 187-197. (IF = 3.3)  
*Role: Clowers devised the experimental approach and parameters for analysis using liquid chromatography and mass spectrometry.*
54. Yu, Z.,\* Miller, H. C., Puzon, G. J., Clowers, B. H. Development of Untargeted Metabolomics Methods for the Rapid Detection of Pathogenic *Naegleria fowleri*. *Environ. Sci. Technol.* 2017, **51** (8), 4210-4219. (IF=5.33)  
*Role: Clowers aided significantly in the construction of the manuscript along with the initial data analysis workflows used in the analysis. Clowers also oversaw the chromatographic and mass spectrometry method development.*
53. Morrison, K. A.,\* Clowers, B. H. Differential Fragmentation of Mobility-Selected Glycans via Ultraviolet Photodissociation and Ion Mobility-Mass Spectrometry. *Journal of the American Society for Mass Spectrometry*. 2017 **28**(6):1236-1241. doi: 10.1007/s13361-017. (IF=2.95)  
*Role: Clowers constructed the optical-vacuum interface and conducted the initial experiments regarding the modes of fragmentation. Clowers also provided the initial experimental outline and the initial figures for publication.*
52. Davis, A.L., Liu, W., Siems, W.F. and Clowers, B.H., Correlation ion mobility spectrometry. *Analyst*. 2017, **142**, 292-301 (IF = 4.1)  
*Role: Clowers developed the pulsing hardware, initial code for generating pulse sequences, the broad experimental outline and direct editorial feedback during manuscript construction.*
51. Craft, R.M., Haas, A.E., Wiley, J.L., Yu, Z.,\* Clowers, B.H. Gonadal hormone modulation of  $\Delta^9$ -tetrahydrocannabinol-induced antinociception and metabolism in female versus male

rats, *Pharmacology Biochemistry and Behavior*, 2016, doi: 10.1016/j.pbb.2016.09.006. (IF = 2.8)

*Role: Clowers devised the experimental approach and parameters for analysis using liquid chromatography and mass spectrometry.*

50. Choy, C.J., Ley, C.R., Davis, A.L., Backer, B.S., Geruntho, J.J., Clowers, B.H., Berkman, C.E. Second-Generation Tunable pH-Sensitive Phosphoramidate-Based Linkers for Controlled Release. *Bioconjugate Chemistry*. 2016 Sep 2;27(9):2206-13. (IF = 4.5)  
*Role: Clowers directed A.L. Davis in the development of a chromatographic method and aided in the analysis protocol used for data interpretation.*
  
49. Morrison, K. A.,\* Bendiak, B.K., Clowers, B.H. Enhanced Mixture Separations of Metal Adducted Tetrasaccharides Using Frequency Encoded Ion Mobility Separations and Tandem Mass Spectrometry. *Journal of the American Society for Mass Spectrometry* (2016): 1-14. (IF = 2.9)  
*Role: Clowers aided in the development of the experimental plan and broad parameters for manipulation. Additional contributions included data analysis, collaborative figure generation, and manuscript editing.*
  
48. Morrison, K A.\*, Siems, W.F., Clowers, B.H. Augmenting Ion Trap Mass Spectrometers Using Drift Tube Ion Mobility and the Fourier Transform. *Analytical Chemistry* 2016, 88 (6), pp 3121–3129. (IF = 5.6)  
*Role: Clowers formulated the experimental plan, hardware configurations, analysis scripts, and provided support and guidance regarding project management, manuscript construction, and figure development.*
  
47. Leiser, O. P.; Merkley, E. D.; Clowers, B. H.; Deatherage Kaiser, B. L.; Lin, A.; Hutchison, J. R.; Melville, A. M.; Wagner, D. M.; Keim, P. S.; Foster, J. T.; et al. Investigation of *Yersinia pestis* Laboratory Adaptation through a Combined Genomics and Proteomics Approach. *PLoS ONE* 2015, 10 (11), e0142997 DOI: 10.1371/journal.pone.0142997. (IF = 3.2)  
*Role: Clowers developed the statistically-based experimental design, instrumental method of analysis, and collected the bulk of the proteomics data outlined in this manuscript.*

46. Clowers, B. H.; Siems, W. F.; Yu, Z.\*; Davis, A. L.\* A two-phase approach to Fourier transform ion mobility time-of-flight mass spectrometry. *Analyst* 2015, 140 (20), 6862–6870. (IF = 4.1)  
*Role: Combined with Dr. Siems, Clowers developed the original concept underpinning this work. The raw pulsing sequences, pulsing hardware, and the bulk of data collection were performed by Clowers. Following the development of the analysis scripts the students Yu and Davis provided support regarding data processing, figure development, and in select cases data collection.*
45. Andy Lin, A., Merkley, E.D., Clowers, B.H., Hutchison, J.R., Kreuzer, H.K. Effects of Bacterial Inactivation Methods on Downstream Proteomic Analysis. *Journal of Microbiological Methods*. 2015, 112, 3–10. (IF = 2.0)  
*Role: In addition to furnishing the initial analysis scripts for this work, Clowers developed the analytical methodology and collected all of the data used in this work.*
44. Prost, S. A., Crowell, K. L., Baker, E. S., Ibrahim, Y. M., Clowers, B. H., Monroe, M. E., Anderson, G.A., Smith, R.D., Payne, S. Detecting and Removing Data Artifacts in Hadamard Transform Ion Mobility-Mass Spectrometry Measurements. *Journal of the American Society for Mass Spectrometry*, 2014, 1-8. (IF = 2.9)  
*Role: Clowers provided the initial pulse sequences used for the experiments along with key algorithmic insights for post-processing analysis of multiplexed data.*
43. Webb-Robertson, B.J.M., Corley, C.D., McCue, L.A., Clowers, B.H., Dowling, C.P. Forensic Signature Detection of *Yersinia pestis* Culturing Practices across Institutions Using a Bayesian Network. *J Forensic Investigation*, 2014. 2(1), 7. (IF = 1.25)  
*Role: This work details a post-hoc analysis of experiments and data acquired by Clowers. Additionally, Clowers distilled the raw data into the formats necessary for comparisons.*
42. Wunschel, D.S., E. Tulman, H. Engelmann, B.H. Clowers, S. Geary, A. Robinson,† L. Xiaofen. Forensic proteomics of poxvirus production. *Analyst*. 2013: 138(21) p. 6385-6397. (IF = 4.1)  
*Role: Clowers provided detailed oversight for the sample and data analysis pipelines including data interpretation.*

41. Wunschel, D.S., H. Engelmann, K. Victry, B.H. Clowers, C. Sorensen, N.B. Valentine, C. Mahoney, Christine, T. Wietsma, K.L. Wahl. Protein markers for identification of *Yersinia pestis* and their variation related to culture. *Molecular and Cellular Probes*. 2014. 28(2-3): p. 65-72  
*Role: Clowers provided detailed oversight for the sample and data analysis pipelines including data interpretation.*
40. Ewing, R.G., B.H. Clowers, D.A. Atkinson. Direct Real-Time Detection of Vapors from Explosive Compounds. *Analytical Chemistry*. 2013. 85(22): p. 10977-10983.
39. Clowers, B.H., D.S. Wunschel, H.E. Kreuzer, H. Engelmann, N.B. Valentine, K.L. Wahl. Characterization of Residual Medium Peptides from *Yersinia pestis* Cultures. *Analytical Chemistry*. 2013. 85(8): p. 3933-3939.
38. Robert Ewing, David A. Atkinson, Brian H. Clowers. Direct Real-Time Detection of RDX Vapors Under Ambient Conditions. *Analytical Chemistry*. 2013. 85(1); p. 389-397.
37. Davis, E.J., B.H. Clowers, W.F. Siems, H.H. Hill. Comprehensive software suite for the operation, maintenance, and evaluation of an ion mobility spectrometer. *International Journal for Ion Mobility Spectrometry*. 2011, 14(2-3): p. 117-124.
36. Froehlich, J.W., M. Barboza, C. Chu, L.A. Lerno, B.H. Clowers, A.M. Zivkovic, J.B. German, and C.B. Lebrilla. Nano-LC-MS/MS of Glycopeptides Produced by Nonspecific Proteolysis Enables Rapid and Extensive Site-Specific Glycosylation Determination. *Analytical Chemistry*, 2011. 83(14): p. 5541-5547.
35. Shah, A.R., J. Davidson, M.E. Monroe, A.M. Mayampurath, W.F. Danielson, Y. Shi, A.C. Robinson, B.H. Clowers, M.E. Belov, G.A. Anderson, and R.D. Smith. An Efficient Data Format for Mass Spectrometry-Based Proteomics. *Journal of the American Society for Mass Spectrometry*, 2010. 21(10): p. 1784-1788.
34. Fraga, C.G., B.H. Clowers, R.J. Moore, and E.M. Zink. Signature-Discovery Approach for Sample Matching of a Nerve-Agent Precursor Using Liquid Chromatography-Mass Spectrometry, XCMS, and Chemometrics. *Analytical Chemistry*, 2010. 82(10): p. 4165-4173.



33. Zhu, M.L., B. Bendiak, B.H. Clowers, and H.H. Hill. Ion mobility-mass spectrometry analysis of isomeric carbohydrate precursor ions. *Analytical and Bioanalytical Chemistry*, 2009. 394(7): p. 1853-1867.
32. Tolmachev, A.V., B.H. Clowers, M.E. Belov, and R.D. Smith. Coulombic Effects in Ion Mobility Spectrometry. *Analytical Chemistry*, 2009. 81(12): p. 4778-4787.
31. Johnson, T.J., Y.F. Su, N.B. Valentine, H.W. Kreuzer-Martin, K.L. Wahl, S.D. Williams, B.H. Clowers, and D.S. Wunschel. The Infrared Spectra of Bacillus Bacteria Part I: Vegetative Bacillus versus Sporulated Cells and the Contributions of Phospholipids to Vegetative Infrared Spectra. *Applied Spectroscopy*, 2009. 63(8): p. 899-907.
30. Dodds, E.D., R.R. Seipert, B.H. Clowers, J.B. German, and C.B. Lebrilla. Analytical Performance of Immobilized Pronase for Glycopeptide Footprinting and Implications for Surpassing Reductionist Glycoproteomics. *Journal of Proteome Research*, 2009. 8(2): p. 502-512.
29. Chu, C.S., M.R. Ninonuevo, B.H. Clowers, P.D. Perkins, H.J. An, H.F. Yin, K. Killeen, S. Miyamoto, R. Grimm, and C.B. Lebrilla. Profile of native N-linked glycan structures from human serum using high performance liquid chromatography on a microfluidic chip and time-of-flight mass spectrometry. *Proteomics*, 2009. 9(7): p. 1939-1951.
28. Beagley, N., C. Scherrer, Y. Shi, B.H. Clowers, W.F. Danielson, and A.R. Shah. Increasing the Efficiency of Data Storage and Analysis Using Indexed Compression. Fifth IEEE International Conference on e-Science. p. 66-71.
27. Seipert, R.R., E.D. Dodds, B.H. Clowers, S.M. Beecroft, J.B. German, and C.B. Lebrilla. Factors that influence fragmentation behavior of N-linked glycopeptide ions. *Analytical Chemistry*, 2008. 80(10): p. 3684-3692.
26. Lopez-Ferrer, D., K. Petritis, N.M. Lourette, B.H. Clowers, K.K. Hixson, T. Heibeck, D.C. Prior, L. Pasa-Tolic, D.G. Camp, M.E. Belov, and R.D. Smith. On-line Digestion System for Protein Characterization and Proteome Analysis. *Analytical Chemistry*, 2008. 80(23): p. 8930-8936.

25. Dodds, E.D., B.H. Clowers, P.J. Hagerman, and C.B. Lebrilla. Systematic characterization of high mass accuracy influence on false discovery and probability scoring in peptide mass fingerprinting. *Analytical Biochemistry*, 2008. 372(2): p. 156-166.
24. Clowers, B.H., Y.M. Ibrahim, D.C. Prior, W.F. Danielson, M.E. Belov, and R.D. Smith. Enhanced ion utilization efficiency using an electrodynamic ion funnel trap as an injection mechanism for ion mobility spectrometry. *Analytical Chemistry*, 2008. 80(3): p. 612-623.
23. Clowers, B.H., E.D. Dodds, R.R. Seipert, and C.B. Lebrilla. Dual polarity accurate mass calibration for electrospray ionization and matrix-assisted laser desorption/ionization mass spectrometry using maltooligosaccharides. *Analytical Biochemistry*, 2008. 381(2): p. 205-213.
22. Clowers, B.H., M.E. Belov, D.C. Prior, F.D. William, Y. Ibrahim, and R.D. Smith. Pseudorandom sequence modifications for ion mobility orthogonal time-of-flight mass spectrometry. *Analytical Chemistry*, 2008. 80(7): p. 2464-2473.
21. Belov, M.E., B.H. Clowers, D.C. Prior, W.F. Danielson, A.V. Liyu, B.O. Petritis, and R.D. Smith. Dynamically multiplexed ion mobility time-of-flight mass spectrometry. *Analytical Chemistry*, 2008. 80(15): p. 5873-5883.
20. Kirmiz, C., B. Li, H.J. An, B.H. Clowers, H.K. Chew, K.S. Lam, A. Ferrige, R. Alecio, A.D. Borowsky, S. Sulaimon, C.B. Lebrilla, and S. Miyamoto. A serum glycomics approach to breast cancer biomarkers. *Molecular & Cellular Proteomics*, 2007. 6(1): p. 43-55.
19. Dwivedi, P., B. Bendiak, B.H. Clowers, and H.H. Hill. Rapid resolution of carbohydrate isomers by electrospray ionization ambient pressure ion mobility spectrometry-time-of-flight mass spectrometry (ESI-APIMS-TOFMS). *Journal of the American Society for Mass Spectrometry*, 2007. 18(7): p. 1163-1175.
18. Clowers, B.H., E.D. Dodds, R.R. Seipert, and C.B. Lebrilla. Site determination of protein glycosylation based on digestion with immobilized nonspecific proteases and Fourier transform ion cyclotron resonance mass spectrometry. *Journal of Proteome Research*, 2007. 6: p. 4032- 4040.

17. Chavarra-Miranda, D., B.H. Clowers, G. Anderson, and M. Belov. Simulating data processing for an advanced ion mobility mass spectrometer, Proceedings of the 1st International Workshop on High-performance Reconfigurable Computing Technology and Applications, ACM: Reno, Nevada. p. 21-29.
16. Baker, E.S., B.H. Clowers, F.M. Li, K. Tang, A.V. Tolmachev, D.C. Prior, M.E. Belov, and R.D. Smith, Ion mobility spectrometry-mass spectrometry performance using electrodynamic ion funnels and elevated drift gas pressures. *Journal of the American Society for Mass Spectrometry*, 2007. 18(7): p. 1176-1187.
15. Ninonuevo, M.R., Y. Park, H.F. Yin, J.H. Zhang, R.E. Ward, B.H. Clowers, J.B. German, S.L. Freeman, K. Killeen, R. Grimm, and C.B. Lebrilla. A strategy for annotating the human milk glycome. *Journal of Agricultural and Food Chemistry*, 2006. 54(20): p. 7471-7480.
14. Dwivedi, P., C. Wu, L.M. Matz, B.H. Clowers, W.F. Siems, and H.H. Hill. Gas-phase chiral separations by ion mobility spectrometry. *Analytical Chemistry*, 2006. 78(24): p. 8200-8206.
13. Clowers, B.H., W.F. Siems, H.H. Hill. and S.M. Massick. Hadamard transform ion mobility spectrometry. *Analytical Chemistry*, 2006. 78(1): p. 44-51.
12. Clowers, B.H. and H.H. Hill. Influence of cation adduction on the separation characteristics of flavonoid diglycoside isomers using dual gate-ion mobility-quadrupole ion trap mass spectrometry. *Journal of Mass Spectrometry*, 2006. 41(3): p. 339-351.
11. Steiner, W.E., S.J. Klopsch, W.A. English, B.H. Clowers, and H.H. Hill. Detection of a chemical warfare agent simulant in various aerosol matrixes by ion mobility time-of-flight mass spectrometry. *Analytical Chemistry*, 2005. 77(15): p. 4792-4799.
10. Clowers, B.H. and H.H. Hill. Mass analysis of mobility-selected ion populations using dual gate, ion mobility, quadrupole ion trap mass spectrometry. *Analytical Chemistry*, 2005. 77(18): p. 5877-5885.
9. Clowers, B.H., P. Dwivedi, W.E. Steiner, H.H. Hill. and B. Bendiak. Separation of sodiated isobaric disaccharides and trisaccharides using electrospray ionization-atmospheric pressure

- ion mobility-time of flight mass spectrometry. *Journal of the American Society for Mass Spectrometry*, 2005. 16(5): p. 660-669.
8. Steiner, W.E., B.H. Clowers, W.A. English, and H.H. Hill. Atmospheric pressure matrix-assisted laser desorption/ionization with analysis by ion mobility time-of-flight mass spectrometry. *Rapid Communications in Mass Spectrometry*, 2004. 18(8): p. 882-888.
  7. Steiner, W.E., B.H. Clowers, and H.H. Hill. Rapid separation of phenylthiohydantoin amino acids: ambient pressure ion-mobility mass spectrometry (IMMS). *Analytical and Bioanalytical Chemistry*, 2003. 375(1): p. 99-102.
  6. Steiner, W.E., B.H. Clowers, P.E. Haigh, and H.H. Hill. Secondary ionization of chemical warfare agent simulants: Atmospheric pressure ion mobility time-of-flight mass spectrometry. *Analytical Chemistry*, 2003. 75(22): p. 6068-6076.
  5. Steiner, W.E., B.H. Clowers, L.M. Matz, W.F. Siems, and H.H. Hill. Rapid screening of aqueous chemical warfare agent degradation products: Ambient pressure ion mobility mass spectrometry. *Analytical Chemistry*, 2002. 74(17): p. 4343-4352.
  4. Matz, L.M., W.E. Steiner, B.H. Clowers, and H.H. Hill. Evaluation of micro- electrospray ionization with ion mobility spectrometry/mass spectrometry. *International Journal of Mass Spectrometry*, 2002. 213(2-3): p. 191-202.
  3. Steiner, W.E., B.H. Clowers, K. Fuhrer, M. Gonin, L.M. Matz, W.F. Siems, A.J. Schultz, and H.H. Hill. Electrospray ionization with ambient pressure ion mobility separation and mass analysis by orthogonal time-of-flight mass spectrometry. *Rapid Communications in Mass Spectrometry*, 2001. 15(23): p. 2221-2226.
  2. Matz, L.M., B.H. Clowers, W.E. Steiner, W.F. Siems, and H.H. Hill, Liquid-sheath-flow electrospray ionization feasibility study of direct water analysis with the use of high-resolution ion-mobility spectrometry. *Field Analytical Chemistry and Technology*, 2001. 5(1-2): p. 91-96.
  1. Clowers, B.H., W.E. Steiner, H.M. Dion, L.M. Matz, M. Tam, E.E. Tarver, and H.H. Hill, Evaluation of sulfonylurea herbicides using high resolution electrospray ionization ion

mobility quadrupole mass spectrometry. *Field Analytical Chemistry and Technology*, 2001. 5(6): p. 302-312.

2.

### Book Chapters

1. Wahl, Karen L., Wunschel, David S. and Clowers, Brian H. 2010. "Proteomics Development and Application for Bioforensics." Chapter 26 in *Microbial Forensics, 2nd Edition*, ed. B Budowle, SE Schutzer, RG Breeze, PS Keim and SA Morse, pp. 449-460. Academic Press/Elsevier, Burlington, MA.

### Patents/Invention Disclosures

Items numbered in bold represent work completed while at WSU.

\*Denotes graduate student contributions.

- 7.** Destruction of Nucleic Acid Chains from Collected Biological Material. Clowers. B.H., Hill, H.H., Lovrich, N., Nosbusch, P.\* Washington State University, 2017. U.S. Provisional Patent 1756.
- 6.** A Device for the Generation of Digital Waveforms with High Resolution Duty Cycle for Creating Digital Waveform Driven Mass Filters. Reilly, P.T.A., Clowers. B.H., Gotlib, Z.,\* Hoffman, N.M.,\* Washington State University, 2017. U.S. Provisional Patent 1792.
- 5.** Particle-based drug detection methods. Hill Jr, H.H., Clowers, B. and Lovrich, N., Washington State University, 2016. U.S. Patent Application 15/217,856.
- 4.** Method for selective detection of explosives in mass spectrometer or ion mobility spectrometer at parts-per-quadrillion level. US9123520B2, 2015.
3. System and process for selective detection of vapor-phase analytes. US Pat. 20130260478, 2013.
2. Ion funnel ion trap and process. US Pat. 12156360, 2010
  - *Licensed by Agilent Technologies 2011*
1. Mass analysis of mobility selected ion populations US Pat. 11582198, 2007
  - *Licensed by ExcellIMS from WSU in 2013*

### Invited and Contributed Oral Presentations

Works numbered in bold represent presentations while WSU faculty.

\*Graduate student contributions

- 28.** *Selective Gas-Phase Clustering: Practical Applications of Cluster Thermodynamics.* Brian H. Clowers, January 30, 2018. Florida State University (Invited Departmental Seminar).
- 27.** *Selective Gas-Phase Clustering: Practical Applications of Cluster Thermodynamics.* Brian H. Clowers, January 29, 2018. University of Florida (Invited Departmental Seminar).
- 26.** *Maximum Resolution and High Throughput: Compressive Sensing and Ion Multiplexing.* Brian H. Clowers and Austen L. Davis,\* Annual Conference for the International Society for Ion Mobility Spectrometry. July 21-25 2017, Warsaw, Poland. (Oral Presentation)
- 26.** *Transformational Approaches for Realizing High Resolution, High Throughput Ion Mobility Measurements: Compressive Sensing and Ion Multiplexing.* Austen L. Davis,\* Brian H. Clowers, Annual Meeting for the American Society for Mass Spectrometry Conference 2017. June 4 -8 2017, Indianapolis, IN. (Oral Presentation)
- 25.** *Tuning Gas-Phase Mobility Separation Factors via Selective Ion-Neutral Clustering.* Brian H. Clowers, May 1, 2017. University of Oregon (Invited Departmental Seminar).
- 24.** *Progress and Challenges to Realizing Roadside Detection of Acute Marijuana Consumption.* Brian H. Clowers, Peyton Nosbusch,\* Herbert H. Hill, & Nicholas Lovrich. April 17, 2017. Azusa Pacific University (Invited Departmental Seminar).
- 23.** *Progress and Challenges to Realizing Roadside Detection of Acute Marijuana Consumption.* Brian H. Clowers, Peyton Nosbusch,\* Herbert H. Hill, & Nicholas Lovrich. March 6, 2017. PITTCON, 2017, Chicago, IL (Oral Presentation).
- 22.** *Frequency Encoded Mobility Separations and Fragmentation Yields for Isomeric Tetrasaccharides.* Brian H. Clowers, Kelsey A. Morrison,\* Brad K. Bendiak. November 3, 2016. Lake Louise, ON (Oral Presentation).

21. *Modification of Drift Gas Composition to Isolate Chemical Classes using Drift-Tube Ion Mobility Mass Spectrometry*. Brian H. Clowers, Zhihao Yu,\* Pearl Kwtani-Barima,\* October 28, 2016. Duquesne University (Invited Departmental Seminar).
20. *Modification of Drift Gas Composition to Isolate Chemical Classes using Drift-Tube Ion Mobility Mass Spectrometry*. Brian H. Clowers, Zhihao Yu,\* Pearl Kwtani-Barima,\* September 19, 2016. Annual Conference of the Federation of Analytical Chemistry and Spectroscopy Societies, September 19, 2016, Minneapolis, MN.
19. *High-Resolution Atmospheric Pressure Drift Tube Ion Mobility Spectrometry Coupled with Ultra-Accurate Mass Orbitrap Mass Spectrometry*. Zambrzycki, Stephen;\* Li, Anyin;\* Keelor, Joel ; Clowers, Brian; Fernandez, Facundo. September 19, 2016. Annual Conference of the Federation of Analytical Chemistry and Spectroscopy Societies, September 19, 2016, Minneapolis, MN. (Oral Presentation)
18. *Accurate mass and mobility speciation of metal complexes: Uranium, barium, cesium, and lanthanum*. Austen L. Davis,\* Brian H. Clowers; 251st American Chemical Society National Meeting and Exposition, 2016, San Diego, CA. (Invited Oral Presentation)
17. *Untangling Gas-Phase Metal Chelation Using Ion Mobility: Strategies and Challenges*. Austen L. Davis,\* Brian H. Clowers; 25th Annual ISIMS Conference, 2016, Boston, MA. (Oral Presentation)
16. *Advancing Mass Spectrometry Beyond m/z Measurements*. Brian H. Clowers. NSF Mass Spectrometry Interest Group, June 3, 2016. San Antonio, TX. (Oral Presentation)
15. *Ion Multiplexing: Tangible Enhancements for Ion Mobility-Mass Spectrometry*. Brian H. Clowers. University of Nebraska, Lincoln. Department of Chemistry Seminary Series. February 2016. (Invited Oral Presentation)
14. *Field Detection and Quantification of Inorganic Species from Surfaces*. Brian H. Clowers, Nathalie A. Wall, Austen Davis\*, Riane Stene\*, Christopher Veldhuizen\*. July 21, 2015. DTRA Basic Science Technical Review. Springfield, VA.

13. *Modification of Drift Gas Composition to Isolate Chemical Classes using Drift-Tube Ion Mobility Mass Spectrometry.* Brian H. Clowers, Ph.D. October 15, 2015. Whitman College, Walla Walla, WA. Department of Chemistry, Seminar
12. *Modification of Drift Gas Composition to Isolate Chemical Classes using Drift-Tube Ion Mobility Mass Spectrometry.* Brian H. Clowers, Ph.D. October 27, 2015. Pacific University, Forest Grove, OR. Department of Chemistry, Seminar
11. *Gas-Phase Approaches to Metal Speciation,* Brian H. Clowers, Austen L. Davis\*. August 4, 2015, Lawrence Livermore National Laboratory. Livermore, CA. DHS/DNDO Academic Collaboration Meeting
10. *Accounting for Gas-Phase Intermediates using Fourier Transform Ion Mobility Mass Spectrometry.* Brian H. Clowers, Austen Davis,\* Zhihau Yu,\* William F. Siems. PITTCON, March 8-12, 2015, New Orleans, LA. (Oral Presentation)
9. *Differential Photofragmentation Patterns for Mobility Selected Glycans.* Kelsey A. Morrison,\* Enamuel H. Khan, Brian H. Clowers. 63rd ASMS Conference on Mass Spectrometry and Allied Topics, June 1, 2015, St. Louis, MO. (Oral Presentation)
8. *What Multiplexing Can Do for Your Experiment: Tangible Enhancements for Ion Mobility Spectrometry.* Brian H. Clowers, Austen Davis,\* Kelsey Morrison\* 42nd Annual Conference of the Federation of Analytical Chemistry and Spectroscopy Societies, October 1, 2015, Providence, RI. (Oral Presentation)
7. *Hybrid Multiplexing Schemes to Enhance Ion Throughput in Ion Mobility-Ion Trap Mass Spectrometry Systems.* Brian H. Clowers, Kelsey Morrison,\* Austen L. Davis.\* 24th International Conference on Ion Mobility Spectrometry, July 28, 2015, Córdoba, Spain. (Oral Presentation)
6. *Metabolite Detection of Naegleria species using Ion Mobility Mass Spectrometry.* X. Zhang,\* Z. Yu,\* Clowers, B. H., Hill, H. H., Miller, H., Puzon, G.J. 2014 American Water Works Association Annual Meeting. "Innovative Microbial Testing Methods," Wednesday, November 19, 2014. Atlanta, GA. (Invited Oral Presentation)



5. *Modification of Drift Gas Composition to Isolate Chemical Classes Using Drift-Tube Ion Mobility Mass Spectrometry.* Brian H. Clowers, Zhihao Yu, \* Austen Davis.\* Oregon State University Mass Spectrometry Symposium. September 24, 2014, Corvallis, OR. (Invited Oral Presentation)
4. *Ion Mobility Multiplexing and Hadamard Encoding Errors,* Brian H. Clowers, Zheng Xing<sup>1</sup>, William F. Siems. Annual Southeastern Regional American Chemical Society Meeting, November 3, 2013, Atlanta, GA. (Invited Oral Presentation)
3. *Media Derived Protein Profiles of Microbial Samples,* Brian H. Clowers, David Wunschel, Nancy B. Valentine, Heather Engelmann, Karen Wahl. White House Interagency Microbial Forensics Advisory Board, Non-Genomic Forensic Signatures, July 12, 2012, Springfield, VA. (Invited Oral Presentation)
2. *Forensic Identification of Growth Conditions Using Residual Medium Peptides.* Brian H. Clowers, Helen Kreuzer, David S. Wunschel, Heather Engelmann, Nancy B. Valentine, Karen L. Wahl. DTRA Chemical and Biological Science and Technology Conference, 2011, Las Vegas, NV. (Invited Oral Presentation)
1. *Analysis of Proteins and Metabolites of Unknown Samples to Complement Genetic Characterizations.* Karen Wahl, Nancy Valentine, Brian H. Clowers, David Wunschel, Christopher Ehrhardt, Heather Engelmann, Angela Melville, Kathryn Antolick, Jon Wahl, Janine Hutchison, Christina Sorensen. DHT Science and Technology Biological Forensics Review, 2011, Alexandria, VA. (Oral Presentation)

### **Conference Presentations**

Since 2005 over 80 scientific presentations have been given in both oral and poster formats at a range of national and international conference venues. Recent presentations include (Bold numbered entries represent work while at WSU, underlined author presented work):

16. *Generation of Digital Waveforms with High Resolution and Duty Cycle.* Nathan Hoffman.\* Zachary Gotlib,\* Brian H. Clowers, Peter T. A. Reilly. Annual Meeting for the American Society for Mass Spectrometry Conference 2017. June 4 -8 2017, Indianapolis, IN. (Poster Presentation)

15. *Assessment of Dimeric Metal-Glycan Adducts via Isotopic Labeling and Ion Mobility-Mass Spectrometry.* Kelsey Morrison,\* Brad K. Bendiak, Brian H. Clowers, Pearl Kwantwi-Barima\*; Annual Meeting for the American Society for Mass Spectrometry Conference 2017. June 4 -8 2017, Indianapolis, IN. (Poster Presentation)
  
14. *Comparative Metabolomic Profiling for Metastatic and Primary Melanoma Cell Lines.* Zhihao Yu,\* Ming Huang, Brian H. Clowers. Annual Meeting for the American Society for Mass Spectrometry Conference 2017. June 4 -8 2017, Indianapolis, IN. (Poster Presentation)
  
13. *Selective Ion-Neutral Clustering to Enhance Ion Mobility Separation Factors.* Pearl Kwantwi-Barima,\* Brian H. Clowers, Annual Meeting for the American Society for Mass Spectrometry Conference 2017. June 4 -8 2017, Indianapolis, IN. (Poster Presentation)
  
12. *Tuning Mobility Separation Factors via Selective Ion-Neutral Clustering.* Brian H. Clowers, Pearl Kwantwi-Barima\*; Gas-Phase Ion Chemistry, Gordon Conference 2017. February 2017, Ventura, CA. (Poster Presentation)
  
11. *Open-Source, Modular Approaches for Ion Mobility Spectrometry.* Brian H. Clowers, Gordon A. Anderson, Kelsey Morrison,\* Peyton Nosbusch,\* Austen L. Davis\*; 25<sup>th</sup> Annual ISIMS Conference, 2016, Boston, MA. (Poster Presentation)
  
10. *Comparing Ion Multiplexing Techniques: Tangible Enhancement for Ion Mobility-Mass Spectrometry.* Brian H. Clowers, Austen L. Davis,\* Kelsey Morrison\*; 64<sup>th</sup> ASMS Conference on Mass Spectrometry and Allied Topic, 2016, San Antonio, TX. (Poster Presentation)
  
9. *Maintaining Speciation of Reactive Gas-Phase Complexes for the Metals Uranyl, Barium, Cesium and Lanthanum with Sulfoxides using AP-IMS-MS.* Austen L. Davis,\* Brian H. Clowers; 64<sup>th</sup> ASMS Conference on Mass Spectrometry and Allied Topics, 2016, San Antonio, TX. (Poster Presentation)
  
8. *Frequency Encoding the Mobility of Isomeric Glycans: Separations Using Drift Tube Ion Mobility and Tandem Mass Spectrometry.* Kelsey A. Morrison; Brad K. Bendiak; Brian H. Clowers; 64<sup>th</sup> ASMS Conference on Mass Spectrometry and Allied Topics, June 6, 2016, San Antonio, TX. (Poster Presentation)

7. *Metabolite-based Detection of Pathogenic Naegleria in Water Distribution Systems using UPLC-MS.* Zhihao Yu, Haylea Miller; Geooffrey Puzon; Brian Clowers; 64th ASMS Conference on Mass Spectrometry and Allied Topics, June 5, 2016. San Antonio, TX (Poster Presentation)
6. *Mass and Mobility Distributions of Labile Metal Complexes of Uranium, Barium, Cesium and Lanthanum.* Austen Davis; Brian H. Clowers; 63rd ASMS Conference on Mass Spectrometry and Allied Topics, June 1, 2015, St. Louis, MO. (Poster Presentation)
5. *Maximizing the Multiplexing Advantage: Mobility-Specific Sources of Transform Error and Means of Correction.* Brian H. Clowers, Xing Zhang, William F. Siems. 62nd American Society for Mass Spectrometry. Baltimore, MD. June 2014. (Poster Presentation)
4. *Optimized metabolite extraction procedure for the detection of Naegleria fowleri in aqueous systems using Ion mobility and Mass Spectrometry.* Yu, Z., Zhang, X., Miller, H., Puzon, G. F., Clowers, B. H. Northwest Regional Meeting of the American Chemical Society, Monday, June 23, 2014. (Poster Presentation)
3. *Rapid analysis of uranium complexes using nanoDESI and Ion Mobility-Mass Spectrometry.* Davis, A. L., Hauck, B., Clowers, B. H. Northwest Regional Meeting of the American Chemical Society, Monday, June 23, 2014. (Poster Presentation)
2. *Multiplexing Strategies for Ion Mobility Spectrometry.* Brian H. Clowers, Xing Zheng, William F. Siems. Annual Southeastern Regional American Chemical Society Meeting, November 3, 2013, Atlanta, GA. (Invited Oral Presentation)
1. *Forensic Characterization of Microbial Growth Conditions using Emergent Peptide Signatures.* Brian H. Clowers, Helen Kreuzer, David S. Wunschel, Heather Engelmann, Nancy B. Valentine, Karen L. Wahl. 5th National Biothreat Conference, 2012, Denver, CO. (Poster Presentation)

## Grants and Research Support

Army PI: Clowers 10/2017 – 10/2018  
Purchase and Assemble Ion Mobility Spectrometer System (IMS), manufactured by WSU  
Role: PI  
Amount: \$86K

Army (DTRA) PI: Clowers 10/2017 – 9/2019  
Option Years for Field Detection and Quantification of Inorganic Species from Surfaces  
Role: PI  
Amount: \$86K

Defense Threat Reduction Agency (DTRA) PI: Clowers 10/2017 – 9/2019  
Option Years for Field Detection and Quantification of Inorganic Species from Surfaces  
Role: PI  
Amount: \$700K

Washington State DSHS PI: Clowers 07/2016 – 07/2017  
Roadside Detection of Marijuana: Accelerating the Pace of Development & Testing  
Role: PI  
Amount: \$250K  
Note: *Project awarded with Clowers as WSU Faculty.*

ADARP Dedicated Marijuana Analysis PI: Clowers 01/2016 – 07/2017  
Alcohol and Drug Abuse Research Program  
Development of Quantitative Marijuana Analysis Approaches for Small Volume Samples  
Role: PI  
Amount: \$31K  
Note: *Project awarded with Clowers as WSU Faculty.*

NSF Chemical Imaging Initiative PI: Clowers 9/2015 – 11/2018  
National Science Foundation  
Development of Radiative Ion-Ion Neutralization as a High Pressure Detection Mechanism for Ion Mobility Spectrometry

Role: PI

Amount: \$385K

Note: *Project awarded with Clowers as WSU Faculty.*

ARO

PI: Clowers

10/2015 – 11/2018

Army Research Office: Chemical Forensics

Real-Time Ultra Trace Detection of Organics from Environmental Matrices

Role: PI

Amount: \$450K

Note: *Project awarded with Clowers as WSU Faculty.*

MUSC13003

PI: Clowers

3/2013 – 02/2016

Department of Homeland Security (DHS/DNDO)

Curriculum and Faculty Development in Technical Nuclear Forensics at Washington State University

Role: PI

Amount: \$200K

Note: *Project awarded with Clowers as WSU Faculty.*

Technical Scientific Working Group

PI: Wahl

5/2014 – 06/2015

Utility of Proteomics in Microbial Forensic Settings

Role: WSU Subcontract

Amount: \$870K (Clowers Subcontract: \$26K)

Note: *This award was proposed by Clowers prior to joining WSU and serves as a joint appointment mechanism.*

Office of Graduate Research, WSU

PI: Clowers

5/2014 – 7/2015

Optically Enhanced Mobility Separations: Selective Assessment of Stereochemistry

Role: PI

Amount: \$26K

Note: *Project awarded as an outcome of the 2014 Grant Writers' Workshop with a subsequent NSF proposal submitted in July of 2014 that is awaiting a decision.*

Defense Threat Reduction Agency (DTRA) PI: Clowers 10/2013 – 9/2016

Field Detection and Quantification of Inorganic Species from Surfaces

Role: co-PI

Amount: \$1050K (Clowers Total: \$572K over three years)

*Note: Basic research award is distributed between Clowers and Wall (WSU) with subcontracts to Oak Ridge and Savannah River National Laboratories.*

Defense Threat Reduction Agency (DTRA) PI: Kreuzer 07/2011-07/2013

Genomic and Phenotypic Characterization of *Yersinia pestis* During Long-term Serial Passaging

Role: Co-Investigator

Amount: \$1110K

*Note: Final project closeout and results were completed after moving to WSU.*

PNNL National Security Directorate LDRD PI: Clowers FY 2011-2012

Statistically Significant Forensic Fingerprinting: Protein Analysis of Biological Agents

Amount: \$180K

NSD PNNL Explosive Initiative LDRD PI: Clowers FY 2009-2010

Enhanced Detection Mechanisms for Ion Mobility Spectrometry

Amount: \$220K

PNNL Data Intensive Computing Initiative LDRD PI: Beagley FY 2008

Intelligent Compression and Data Organization for Multidimensional Data Volumes

Amount: \$56K

## Service

### Symposium Organization

“Advances in Ion Mobility Spectrometry.” 2017 Scientific Exchange (SciX), September 19, 2017, Reno, NV.

“Ion Mobility: Adding New Dimensions.” 2016 Scientific Exchange (SciX), September 19, 2016, Minneapolis, MN.

“Fundamentals of Atmospheric Pressure Ionization Techniques.” 2013 American Society for Mass Spectrometry Annual Meeting, Baltimore, MD.

### Professional Service

Complex Chemical Systems Dynamics Initiative Advisory Committee, PNNL LDRD  
2017-Present

Treasurer Elect, 2015-2017 International Society for Ion Mobility Spectrometry

Treasurer, 2017-Present, International Society for Ion Mobility Spectrometry

ASMS Short Course Instructor, 2013-Present: Ion Mobility Mass Spectrometry

International Society for Ion Mobility Spectrometry Short Course Instructor, 2015-Present

ASMS Ion Mobility Interest Group Organizer, 2017-2019

ASMS Undergraduate Poster Competition Judge, 2013-Present

### WSU Committees

- Member of the 2013 WSU Analytical Chemistry Faculty Search Committee. (2013-2014).
- Member of the 2014 WSU Tissue and Proteomics Imaging Laboratory Personnel Search Committee. (2014-2015).
- Member of the Graduate Student Admissions Committee. (Spring 2014-Present).

### Peer Reviewing Activities

**43 Peer reviewed recommendations submitted since 2013**

#### Journals:

- Analytical Chemistry
- Journal of the American Society for Mass Spectrometry
- Journal of Mass Spectrometry

- Journal of Chromatography A
- Physical Chemistry Chemical Physics
- International Journal for Ion Mobility Spectrometry
- Analyst
- Talanta

**Agency Service:**

- DOE SBIR
- PNNL/EMSL
- NSF
  - Career and MRI Reviewer
- NIH
  - MRI and P41 Review Panels



**Mentoring**

**Graduate Students**

Austin Davis	(09/2013 – Present)	Anticipated Graduation 2018
Zhihao (Joe) Yu	(11/2013 – Present)	Anticipated Graduation 2018
Kelsey Morrison	(07/2014 – Present)	Anticipated Graduation 2019
Pearl Kwantwi-Barima	(10/2015 – Present)	Anticipated Graduation 2020
Peyton Nosbusch	(5/2016 – Present)	Anticipated Graduation 2021
Caroline Naylor	(10/2016 – Present)	Anticipated Graduation 2021
Andrew Pemberton	(10/2016 – Present)	Anticipated Graduation 2021
Megan Nims	(9/2016 – Present)	Anticipated Graduation 2020

**Undergraduate Students**

Garret Radley (09/2013 – 05/2014)	Graduated 2014, Mechanical Engineering
Amikan Baleswarikan (09/2013 – 05/2016)	Graduation 2017, Electrical Engineering
Noor Alaa Aly (09/2014 – 05/2015)	Graduated 2015, Biology
Thomas Williams (05/2015 – 05/2015)	Graduated 2015, Mechanical Engineering
John Rodgers (01/2016 – 5/2016)	Graduated 2016, Chemistry

## Teaching Experience

### CHEM528 – Data Analysis in Chemistry

- Spring 2018: 17 Students
  - Critiques: TBD

### CHEM520 – Advanced Analytical Chemistry

- Fall 2013: 35 Students
  - Critiques: Team Taught (Clowers contribution: 3 weeks). No specific comments were provided.
- Fall 2015: 28 Students
  - Critiques: Team Taught (Clowers contribution: 3 weeks); Instructor 3.9/5; Course 2.8/5;

### CHEM425 – Instrumental Analysis

- Spring 2014: 12 Students
  - Critiques: Instructor 3.7/5; Course 3.3/5

### CHEM220 – Quantitative Chemical Analysis

- Fall 2014: 37 Students
  - Critiques: Instructor 4.0/5; Course 3.6/5
- Fall 2017: 35 Students
  - Critiques: TBD

### CHEM592 – Analytical Chemistry Seminar

- Fall 2015: 8 Students
  - Critiques: Instructor 4.0/5; Course 4.0/5

### CHEM106 – General Chemistry

- Spring 2015: 200 Students
  - Critiques: Instructor 3.2/5; Course 2.9/5
- Spring 2016: 162 Students
  - Critiques: Instructor 3.8/5; Course 3.6/5

CHEM517 – Chromatography

- Fall 2016: 17 Students
  - Critiques: Instructor 4.1/5; Course 3.6/5