SUSAN C.J. SUMNER

Susan C. J. Sumner, PhD

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Education

Staff Fellow, Spectroscopy, National Institutes of Health, Bethesda, MD, 1986 to 1989.

Ph.D., Physical Chemistry, North Carolina State University, Raleigh, NC, 1986.

B.S., Chemistry (minor: Biology), North Carolina State University, Raleigh, NC, 1982.

Professional Experience

2016. The University of North Carolina at Chapel Hill

Nominated Professor

2004 to 2016. RTI International, Research Triangle Park (RTP), NC.

Director, Untargeted Analysis Core for the Children's Health Exposure Analysis (CHEAR) Hub (2015 to date).

Director, Metabolomics Core for the Center for Human Health and Environmental at NCSU (2015 to date).

Director, NCATS funded Metabolomics Core for the N.C. Translational Sciences Institute at UNC-CH (2013 to date).

Director, Systems and Translational Sciences (STS) Center (2013 to 09/2016).

Adjunct Professor, Nutrition, University of North Carolina at Chapel Hill, (2012 to date).

Director, NIH Common Fund Eastern Regional Comprehensive Metabolomics Research Center (2012 to date).

Adjunct Faculty, Brody School of Medicine, East Carolina University, Greenville (2009 to date).

Senior Scientist 2, Center for Estimating Human Health Risks from Exposure to Nanoparticles (2009 to date).

2001 to 2004. Paradigm Genetics, Inc., RTP, NC.

Manager, Contracts Research (2003 to 2004).

Head, Biochemical Profiling (2002 to 2004).

Staff Scientist (2001 to 2002).

1989 to 2001. Chemical Industry Institute of Toxicology (CIIT), RTP, NC.

Scientist 3, Center for Integrated Genomics, Department of Chemical Carcinogenesis, and Manager, NMR Facility (1999 to 2001).

Scientist 2, Department of Cancer Research, and Manager, NMR Facility (1995 to 1999).

Scientist 1, Department of Biochemical Toxicology, and Manager, NMR Facility (1989 to 1995).

1987 to 1989. National Institutes of Health, Bethesda, MD.

Staff Fellow, Laboratory of Chemistry, NHLBI, NIH.

1979 to 1986. North Carolina State University, Raleigh, NC.

Graduate Student (Physical Chemistry, Specialty in Spectroscopy), Department of Chemistry (1982 to 1986).

Undergraduate Student, Grader and Teaching Assistant, and Researcher, Department of Chemistry (1979 to 1982).

Selected Continued Education

Three I's (IACUC, IBC and IRB) Conference- 2012

Institutional Animal Care and Use Committee (IACUC) Training, 2001 to date.

Leading Change, 2012.

Management Dimensions for Effective Leadership, 2011.

Human Subject Research Training, 2011.

Bloodborne Pathogen, Radioactivity, and Safety Training, 2011.

One-on-One Executive Coaching for Leadership, 2002 to 2004 and 2010.

American Red Cross Adult/Child/Infant First Aid, Cardiopulmonary Resuscitation (CPR), automated external defibrillator (AED), renewed 2010.

PBPK and PKPD Models, Hamner Institutes, 2010.

GLP for QA and GLP Study Directors CIIT, 1995–2002, and RTI, 2004 to 2008.

Leadership Advantage (external consultant), RTI, 2007.

Understanding Computerized System Validation, Info Strength, 2004.

Validation and Control of Bioanalytical Methods, 2000.

Harassment Training, Capitol Associated Industries, Inc., 1998.

The Supervisor and Positive Human Relations, Capitol Associated Industries, Inc., 1998.

Managing Multiple Projects, Objectives, & Deadlines, American Management Association (AMA), 1996.

Criticism/Discipline Skills for Managers, AMA, 1996.

Supervising the Difficult Employee, Capitol Associated Industries, Inc., 1994.

Applications of NMR Spectroscopy in Toxicology, Society of Toxicology (SOT), 1993.

The Newly Appointed Supervisor, Capitol Associated Industries, Inc., 1992.

Writing for Non-scientist Readers, ERG, Inc., 1992.

Effective Presentations, R.J. Kulda, Professional Eloquence, 1991.

Project Management, Applied Management Associates, 1990.

Assertiveness Training, AMA, 1990.

Honors and Awards

Recipient, RTI Awards: Career Author Award, Science and Engineering Performance Award, Outstanding Paper, Highly Cited Author, Highly Published Author, Annual Award for Collaborative Research, President's Award, and Best Paper Award, 2005 to 2016.

Recipient, Best Paper Award, (for Church, R.J., H. Wu, M. Mosedale, S.J. Sumner, W. Pathmasiri, L. Kurtz, et al. 2014. A systems biology approach utilizing a mouse diversity panel identifies genetic differences influencing isoniazid-induced microvesicular steatosis. *Toxicological Sciences 140*:481–492), 2014.

Recipient, Internal Research and Development (IR&D) Award: Influence of the Physiological State of Obesity on the Distribution of Nanoparticles, RTI, 2010.

Recipient, IR&D Award: Maternal and Child NanoHealth: Distribution of [^{14}C]C60 in the Pregnant and Lactating Rat and Effects on Endogenous Metabolism, RTI, 2008.

Recipient, Professional Development Award: Biomarkers, RTI, 2007 to 2008.

Recipient, IR&D Award: Dietary Influences of Phytoestrogens During Pregnancy on Biochemical Mechanisms in Developing Offspring, RTI, 2007.

Recipient, IR&D Award: Dietary Influences of Phthalates During Pregnancy on the Biochemical Mechanisms of the Developing Offspring, RTI, 2006.

Memberships in Scholarly and Professional Organizations

Elected, Board of Directors, Metabolomics Society: 2016 to 2018.

Elected, Board of Directors, Metabolomics Society: 2014 to 2016.

Elected Chair, North Carolina Section of ACS (membership of approximately 2,600), 2002.

Member, North Carolina Biotechnology Center (NCBC) Genomics and Bioinformatics Consortium: 2000 to 2002.

Advisor, Acrylamide Monomer Producers Association: 1999 to 2002.

Advisor, Styrene Information and Research Center: 1997 to 2002.

Full Member, Society of Toxicology, Active: 1990 – 2014.

Member, American Chemical Society (ACS) and/or North Carolina Chapter of ACS: 1986 – date.

Bibliography

Book Chapters

1. **Sumner, S. C. J**., Pathmasiri, W., Carlson, J. E., McRitchie, S. L., & Fennell, T. R. (2016). Metabolomics. Chapter 5 in *Molecular and Biochemical Toxicology (5th edition).* Eds. R.C. Smart and E. Hodgson). J Wiley and Sons: NY, NY. Accepted and in press (15 pages estimate).

2. Stewart, D., Dhungana, S., Clark, R., Pathmasiri, W., McRitchie, S., & **Sumner, S.** (2015). Omics technologies used in systems biology. In R. C. Fry (Ed.), *Systems Biology in Toxicology and Environmental Health: From the Genome to the Epigenome* (1st edition). (pp. 57-84). London, UK: Elsevier.

3. Pathmasiri, W., R.W. Snyder, J.P. Burgess, J.A. Popp, T.R. Fennell, and **S.C.J. Sumner** (2011). Biomakers for the assessment of acetaminophen induced liver injury. (pp. 299–324) Chapter 3 in *General, Applied, and Systems Toxicology*. Edited by D. Casiano and S.C. Saru. John Wiley & Sons Ltd., Hoboken, NJ. January. DOI: 10.1002/9780470744307.gat219.

4. **Sumner, S**., R. Snyder, J. Burgess, R. Tyl, and T. Fennell. (2010). Omics in reproductive and developmental toxicology. (pp 372-384) Chapter 22 in *Reproductive Toxicology*, Third Edition. Edited by R. Kapp and R. Tyl. September. New York, N.Y., Informa Healthcare.

5. Fennell, T.R., and **Sumner, S.C.J.** (2000). Labelling studies in biochemistry using NMR. In *Encyclopedia of Spectroscopy and Spectrometry.* Edited by J.C. Lindon, G.E. Tranter, and J.L. Holmes. (pp. 1097-1104). San Diego, CA: Academic Press.

Refereed Articles

1. Szabo, D. T., Pathmasiri, W., **Sumner, S**., & Birnbaum, L. S. (2016). Different serum metabolomics profiles in neonatal mice following oral brominated flame retardant exposures to hexabormocyclododecane (HBCD) alpha, gamma, and commercial mixture. *Environmental Health Perspectives.* Accepted March 2016, *in press. (7 pages estimate).*

2. Livanos, AE., Greiner, T.U., Vangay, P., Pathmasiri, W., Stewart, D., McRitchie, S., Li, H., Chung, J., Sohn, J., Kim, S., Gao, Z., Barber, C., Kim, J., Ng, S., Rogers, A.B, **Sumner, S**., Zhang, X-S., Cadwell, K., Knights, D., Alekseyenko, A., Bäckhed, F., and Blaser, M.J (2016). Antibiotic-mediated gut microbiome perturbation accelerates development of type 1 diabetes in mice. *Nature Microbiology, 1, Article number:16140; doi:10.1038/nmicrobiol.2016.140. (7 pages estimate).*

3. Fennell T.R., Mortensen N.P., Levine K., Black S.L., Snyder R.W., Holland N.A., Poitras E., Harrington J., Pathmasiri W., Wingard C.J., **Sumner S. J.** (2016). Disposition of Intravenously or Orally Administered Silver Nanoparticles in Pregnant Dams and the Effect on the Biochemical Profile in Urine. *Journal of Applied Toxicology. Oct 3.DOI: 10.1002/jat.3387. PMID 27696470. (8 pages estimate).*

4. Ewald, R and **Sumner, S.J.** (2016). Blood Type Biochemistry and Human Disease *Wiley Interdisciplinary Reviews. Systems biology and medicine. Nov;8(6):517-535. doi: 10.1002/wsbm.1355. Epub 2016 Sep 7.*

5. Dhungana, S., Carlson, J.E., Pathmasiri, W., McRitchie, S., Davis, M., **Sumner, S**, and Appt, Sue. (2016). Impact of Western Diet on the Ovarian and Serum Metabolome. *Journal of Maturitas. Oct; 92:134-42.* doi: 10.1016/j.maturitas.2016.07.008. Epub 2016 Jul 14. PMID: 27621251.

6. Stewart, DA, Winnike, JH, McRitchie, SL, Clark, RF, Pathmasiri, WW, and **Sumner, SJ**. Metabolomics Analysis of Hormone-Responsive and Triple-Negative Breast Cancer Cell Responses to Paclitaxel Identify Key Metabolic Differences. (2016). *Journal of Proteome Research, Sep 2;15(9):3225-40. PMID: 2744733.*

7. Dennis, K. K., Auerbach, S. S., Balshaw, D. M., Cui, Y., Fallin, M. D., Smith, M. T., Spira, A., **Sumner, S**., and Miller, G. (2016). The importance of the biological impact of exposure to the concept of the exposome. Environmental Health Perspectives. 2016 Oct;124(10):1504-1510. DOI:10.1289/EHP140. PMID: 27258438.

8. Mercier K., McRitchie S, Pathmasiri W., Novokhatny A., Koralkar R., Askenazi D., Brophy P.D., **Sumner, S**. (2016) Preterm Neonatal Urinary Renal Developmental and Acute Kidney Injury Metabolomic Profiling: An Exploratory Study. *Pediatric Nephrology. PMID: 27435284, DOI: 10.1007/s00467-016-3439-9. (10 pages estimate).*

9. Gelaye B, **Sumner S**, McRitchie S, Carlson JE, Ananth CV, Enquobahrie DA, Chunfang Q, Sorensen TK, Williams MA (2016). Maternal Early Pregnancy Serum Metabolomics Profile and Abnormal Vaginal Bleeding as Predictors of Placental Abruption: A Prospective Study. *PlosOne 11(6):e0156755. doi:10.1371/journal.pone.0156755. PMID: 27300725*. (*9 pages estimate*).

10. Mortensen NP, Mercier KA, McRitchie S, Cavallo T, Pathmasiri W, Stewart D, and **Sumner S** (2016). Microfluidics Meets Metabolomics to Reveal the Impact of *Campylobacter jejuni* Infection on Biochemical Pathways. *Biomedical Microdevices 18(3):51. doi: 10.1007/s10544-016-0076-9. PMID: 27231016* (*8 pages estimate*).

11. Wang, W., Liang, S., Gao, J., Sun, C., Wang, J., Xia, W, **Sumner, S. J**., Zhang, F., Sun, C., and Wu, L. (2016). Potential serum biomarkers from metabolomics study of autism potential serum biomarkers from metabolomics study of autism. *Journal of Psychiatry and Neuroscience, 41*(1), 27–37. PMID: 26395811, PMCID: PMC4688025.

12. Sandlers, Y., Mercier, K., Pathmasiri, W., Carlson, J., McRitchie, S., **Sumner, S**., and Vernon, H.J. (2016). Metabolomics reveals new mechanisms for pathogenesis in Barth syndrome and introduces novel roles for cardiolipin in cellular function. PLoS ONE, 11(3), e0151802. PMID: 27015085. DOI: 10.137/journal.pone.0151802. (*10 pages estimate*).

13. Loeser, L. R., Jr., Pathmasiri, W., **Sumner, S**., McRitchie, S., Beavers, D., Saxena, P., Nicklas, B.J., Guermazi, A., Hunter, D.J., Messier, S.P. (2016) Association of urinary metabolites with radiographic progression of knee osteoarthritis in overweight and obese adults. *Osteoarthritis Cartilage, Aug;24(8):1479-86. DOI: 10.1016/j.joca.2016.03.011. PMID: 27012755.*

14. Harrington, J. M., Young, D. J., Fry, R. C., **Sumner, S. J**., & Levine, K. E. (2016). Validation of a metallomics analysis of placenta tissue by inductively-coupled plasma mass spectrometry. *Biological Trace Element Research,* 169(2), 164–173.

15. Sumner, L. W., Styczynski, M., McLean, J., Fiehn, O., Jander, G., Liao, J., **Sumner, S**., et al. (2015). Introducing the USA Plant, Algae, and Microbial Metabolomics Research Coordination Network (PAMM-NET). *Metabolomics, 11*(1), 3–5.

16. Holland, N. A., Becak, D. P., Shannahan, J. H., Brown, J. M., Carratt, S. A., Winkle, L., Pinkerton, K.E., Wang, C.M., Munusamy, P., Baer, D.R., **Sumner, S. J**., Fennell, T.R., Lust, R.M., and Wingard, C.J. (2015). Cardiac ischemia reperfusion injury following instillation of 20 nm citrate-capped nanosilver. *Journal of Nanomedicine and Nanotechnology,* S6-006. doi:10.4172/2157-7439.S6-006. PMID: 26966636. (*11 pages estimate*).

17. Sud, M., Fahy, E., Cotter, B., Azam, K., Vadivelu, I., Burant, C. F., Edison, A., Fiehn, O., Higashi, R., Nair, K. S., **Sumner, S.**, & Subramaniam, S. (2016). Metabolomics Workbench: An international repository for metabolomics data and metadata, metabolite standards, protocols, tutorials and training, and analysis tools. *Nucleic Acids Research, 44*(D1), D463–70.

18. Snyder, R. W., Fennell, T. R., Wingard, C. J., Mortensen, N. P., Holland, N. A., Shannahan, J. H., Pathmasiri, W., Lewin, A., and **Sumner, S. C**. (2015). Distribution and biomarker of carbon-14 labeled fullerene C60 ([^{14}C(U)]C60) in pregnant and lactating rats and their offspring after maternal intravenous exposure. *Journal of Applied Toxicology, 35*(12), 1438–1451. doi: 10.1002/jat.3177. PMID: 26081520.

19. Milner, J., Rebeles, J., Dhungana, S., Stewart, D. A., **Sumner, S. C.**, Meyers, M. H., Mancuso, P., and Beck, M.A. (2015). Obesity increases mortality and modulates the lung metabolome during pandemic H1N1 influenza virus infection in mice. *Journal of Immunology, 194(10), 4846–4859. doi: 10.4049/jimmunol.1402295. Epub 2015 Apr 10.*

20. **Sumner, S. C**., Snyder, R. W., Wingard, C., Mortensen, N. P., Holland, N. A., Shannahan, J. H., et al. (2015). Distribution and biomarkers of carbon-14 labeled fullerene C60 ([^{14}C(U)]C60) in female rats and mice for up to 30 days after intravenous exposure. *Journal of Applied Toxicology, 35*(12), 1452–1464. doi: 10.1002/jat.3110. PMID: 25727383.

21. Pratt, K. J., McRitchie, S., Collier, D. N., Lutes, L. D., & **Sumner, S**. (2015). Parent & family influences on adopting healthy weight-related behaviors: Views and perceptions of obese African-American female adolescents. *Journal of the National Medical Association, 107*(2), 74–79.

22. Poitras, E. P., Levine, M. A., Harrington, J. M., Essader, A. S., Fennell, T. R., Snyder, R. W., … **Sumner, S. J**., et al. (2015). Development of an analytical method for assessment of silver nanoparticle content in biological matrices by inductively-coupled plasma mass spectrometry. *Biological Trace Element Research, 163*(1–2), 184–192.

23. Mazagova, M., Wang, L., Anfora, A. T., Wissmueller, M., Lesley, S. A., Miyamoto, Y., … **Sumner, S**., et al. (2015). Commensal microbiota is hepatoprotective and prevents liver fibrosis in mice. *The FASEB Journal: Official Publication of the Federation of American Societies for Experimental Biology, 29*(3), 1043–1055.

24. Vidanapathirana, A. K., Thompson, L. C., Odom, J. T., Holland, N. A., **Sumner, S. J**., Fennell, T. R., et al. (2014). Vascular tissue contractility changes following late gestational exposure to multi-walled carbon nanotubes or their dispersing vehicle in Sprague Dawley rats. *Journal of Nanomedicine and Nanotechnology, 5*(3), 1–15.

25. Wingard, C. J., Holland, N. A., Thompson, L. C., Brown, J. M., Lewin, A. H., **Sumner, S. J**., et al. (2014) The need for reflective consideration of an integrative understanding of cardiovascular consequences to PVP formulated C60 exposure. *Toxicological Sciences, 141*(2):327–328.

26. Vidanapathirana, A. K., Thompson, L. C., Mann, E. E., Odom, J. T., Holland, N. A., **Sumner, S. J**., et al. (2014). PVP formulated fullerene (C60) increases Rho-kinase dependent vascular tissue contractility in pregnant Sprague Dawley rats. *Reproductive Toxicology, 49C*, 86–100.

27. Harrington, J. M., Young, D. J., Essader, A. S., **Sumner, S. J.,** & Levine, K. E. (2014). Analysis of human serum and whole blood for mineral content by ICP-MS and ICP-OES: Development of a mineralomics method. *Biological Trace Element Research, 160*(1), 132–142.

28. Church, R. J., Wu, H., Mosedale, M., **Sumner, S. J.**, Pathmasiri, W., Kurtz, C. L., et al. (2014). A systems biology approach utilizing a mouse diversity panel identifies genetic differences

influencing isoniazid-induced microvesicular steatosis. *Toxicological Sciences, 140*(2), 481–492. (Awarded Best Paper of the Year).

29. Thompson, L. C., Urankar, R. N., Holland, N. A., Vidanapathirana, A. K., Pitzer, J. E., Han, L., **Sumner, S. J**., et al. (2014). C60 exposure augments cardiac ischemia/reperfusion injury and coronary artery contraction in Sprague Dawley Rats. *Toxicological Sciences 138*(2), 365–378.

30. Vidanapathirana, A. K., Lai, X., Hilderbrand, S. C., Pitzer, J. E., Podila, R., **Sumner, S. J**., et al. (2012). Multi-walled carbon nanotube directed gene and protein expression in cultured human aortic endothelial cells is influenced by suspension medium. *Toxicology, 302*(2–3), 114–122.

31. Banerjee, R., Pathmasiri, W. W., Snyder, R., McRitchie, S., & **Sumner, S.** (2012). Metabolomics of brain and reproductive organs: Characterizing the impact of gestational exposure to butylbenzyl phthalate on dams and resultant offspring. *Metabolomics*, *8*(6), 1012–1025.

32. Pathmasiri, W. W., Pratt, K. J., Collier, D. N., Lutes, L. D., McRitchie, S., & **Sumner, S. C.** (2012). Integrating metabolomic signatures and psychosocial parameters in responsivity to an immersion treatment model for adolescent obesity. *Metabolomics*, *8*(6), 1037–1051.

33. Gika, H.G., Theodoridis, G.A., Earl, M., **Sumner, S**., and Wilson. I.D. (2010). Does the mass spectrometer define the marker? A comparison of global metabolite profiling data generated simultaneously via UPLC-MS on two different mass spectrometers. *Analytical Chemistry 82*(19):8226–8234.

34. **Sumner, S. C**., Burgess, J., Snyder, R., Popp, J., & Fennell, T. R. (2010). Metabolomics of urine for the assessment of microvesicular lipid accumulation in the liver following isoniazid exposure. *Metabolomics*, *6*(2), 238–249.

35. **Sumner, S. J**., Fennell, T. R., Snyder, R. W., Taylor, G., & Lewin, A. H. (2010). Distribution of carbon-14 labeled C60 ([14C]C60) in the pregnant and in the lactating dam and the effect of C60 exposure on the biochemical profile of urine. *Journal of Applied Toxicology, 30*(4), 354–360.

36. **Sumner, S.C.J**., R. Snyder, J. Burgess, C. Myers, R. Tyl, C. Sloan, and T. Fennell. 2009. Metabolomics in the assessment of chemical-induced reproductive and developmental outcomes using non-invasive biological fluids: Application to the study of butylbenzyl phthalate. *Journal of Applied Toxicology 29*(8):703–714.

37. Mosquin, P.L, Licata, A.C., Liu, B., **Sumner, S.J**., and Okino, M. (2009). Reconstructing exposures from small samples using physiologically based pharmacokinetic (PBPK) models and multiple biomarkers. *Journal of Exposure Science and Environmental Epidemiology 19*(3):284–297.

38. **Sumner, S.C.J**., and T.R. Fennell. (2007). Biomarkers, omics, and species comparisons. *Human and Ecological Risk Assessment 13*(1):111–119.

39. Garner, C., C. Sloan, S.C. **Sumner, J**. Burgess, J. Davis, A. Etheridge, A. Parham, and B.I. Ghanayem. (2007) CYP2E1-catalyzed oxidation contributes to the sperm toxicity of 1-bromopropane in mice. *Biology of Reproduction 76*(3):496–505.

40. Garner, C.E., **Sumner, S.C.J.**, Davis, J.G., Burgess, J.P., Yueh, Y., Demeter, J., Zhan, Q., Valentine, J., Jeffcoat, A.R., Burka, L.T., and Mathews, J.M. (2006) Metabolism and disposition

of 1-bromopropane in rats and mice following inhalation or intravenous administration. *Toxicology and Applied Pharmacology 215*(1):23–36.

41. Fennell, T.R., **Sumner, S.C.**, Burgess, J., Snyder, R.W., and Friedman, M.A. (2006). Kinetics of elimination of urinary metabolites of acrylamide in humans. *Toxicological Sciences 93*(2):256–267.

42. Fennell, T.R., **Sumner, S.C**, Snyder, R.W., Burgess, J., Spicer, R., Bridson, W.E., and Friedman, M.A. (2005). Metabolism and hemoglobin adduct formation of acrylamide in humans. *Toxicological Sciences 85*(1):447–459.

43. Weis, B.K., Balshaw, D., Barr, J.R, Brown, D., Ellisman, M., Lioy, P., Omenn, G., Potter, J.D., Smith, M.T., Sohn, L., Suk, W.A., **Sumner, S**., Swenberg, J., Walt, D.R., Watkins, S., Thompson, C., and Wilson, S. (2005). Personalized exposure assessment: promising approaches for human environmental health research. *Environmental Health Perspectives 113*(7):840–848.

44. Xirasager, S., Gustafason, S., Merrick, A., Tomer, K., Stasiewicz, S., Chan, D.D., Yost, J., Yates, J.R., **Sumner, S.**, Ziao, N., and Waters, M.D. (2004). CEBS object model for systems biology data. CEBS MAGE SysBio-Om. *Bioinformatics 20*(13):2004–2015.

45. Fennell, T.R., Krol, W.L., **Sumner, S.C.**, and Snyder, R.W. (2004). Pharmacokinetics of dibutylphthalate in pregnant rats. *Toxicological Sciences 82*:407–418.

46. Fennell, T.R., Snyder, R., Krol, W.L., and **Sumner, S.C.J.** (2003). Comparison of the hemoglobin adducts formed by administration of N-methylolacrylamide and acrylamide to rats. *Toxicological Sciences 71*(2):164–175.

47. **Sumner, S.C.J**., Janszen, D.B., Asgharian, B., Moore, T.A., Bobbitt, C.M., and Fennell, T.R. (2003). Blood pharmacokinetics of tertiary amyl methyl ether in male and female F344 rats and CD-1 mice after nose-only inhalation exposure. *Journal of Applied Toxicology 23*(6):419–425.

48. **Sumner, S.C.J.**, Asgharian, B., Moore, T.A., Parkinson, H., Bobbitt, C.M., and Fennell, T.R. (2003). Characterization of metabolites and disposition of tertiary amyl methyl ether in male F-344 rats following inhalation exposure. *Journal of Applied Toxicology 23*:411–417.

49. **Sumner, S.C.J.,** Janszen, D.B., Asgharian, B., Moore, T.A., Parkinson, H.D., and Fennell, T.R. (2003). Species and gender differences in the metabolism and distribution of tertiary amyl methyl ether in male and female rats and mice after inhalation exposure or gavage administration. *Journal of Applied Toxicology 23*:427–436.

50. **Sumner, S.C**., Williams, C.C., Snyder, R.W., Krol, W.L., Asgharian, B., and Fennell, T.R. (2003). Acrylamide: A comparison of metabolism and hemoglobin adducts in rodents following dermal, intraperitoneal, oral, or inhalation exposure. *Toxicological Sciences 75*(2):260–270.

51. Banajamali, A., DeMatteo, V., and **Sumner, S.C.J.** (2003). A mechanism for the formation of bis-glutathione conjugates of propargyl alcohol. *Pest Management Science 59*:331–338.

52. Ghanayem, B.I., Wang, H., and **Sumner, S.C.J.** (2000). Using cytochrome P450 gene knockout mice to study chemical metabolism, toxicity, and carcinogenicity. *Toxicologic Pathology 28*(6):839–850.

53. Johanson, G., Ernstrad, L., Gullstrand, E., Löf, A., Osterman-Golkar, S., Williams, C., and **Sumner, S.** (2000). Styrene oxide in blood, hemoglobin adducts, and urinary metabolites in human volunteers exposed to (13)C(8)-styrene vapors. *Toxicology and Applied Pharmacology 168*(1):36–49.

54. Snyder, R.W., Maness, S.C., Gaido, K.W., Welsch, F., **Sumner, S.C.J.**, and Fennell, T.R. (2000). Metabolism and disposition of bisphenol A in female rats. *Toxicology and Applied Pharmacology 168*(3):225–234.

55. Boogaard, P.J., **Sumner, S.C.J**., de Kloe, K.P., van Elburg, P.A., and Wong, B.A. (2000). Disposition of [ring-U-^{13}C]styrene in rats and mice exposed by recirculating nose-only inhalation. *Toxicological Sciences 58*(1):161–172.

56. Boogaard, P.J., de Kloe, K.P., Wong, B.A., **Sumner, S.C.J.**, Watson, W.P., and van Sittert, N.J. (2000). Quantification of DNA adducts formed in liver, lungs, and isolated lung cells of rats and mice exposed to ^{13}C-styrene by nose-only inhalation. *Toxicological Sciences 57*(2):203–216.

57. Banajamali, A.R., Xu, Y., DeMatteo, V., Strunk, R.J., Gay, M.H., Putterman, G.J., and **Sumner, S.** (2000). Identification of metabolites of [1,2,3-^{13}C]propargyl alcohol in mouse urine by 13C NMR and mass spectrometry. *Journal of Agricultural and Food Chemistry 48*(10):4693–4710.

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59. Nihlén, S., **Sumner, S.**, Löf, A., and Johanson, G. (1999). ^{13}C-Labelled methyl tertiary-butyl ether (^{13}C2-MTBE): toxicokinetics and characterization of urinary metabolites in humans. *Chemical Research in Toxicology 12*(9):822–830.

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Manuscripts Submitted and in Preparation

1. Laine J., Bailey K., Olshan A., Smeester L., Drobná Z., Stỳblo M., García-Vargas G., Rubio-Andrade M., Pathmasiri W., McRitchie S., **Sumner S**., Fry R. Prenatal Arsenic Exposure and the Fetal Metabolome; Inter-Individual Differences in Fetal Metabolomic Profiles Related to Maternal Arsenic Biotransformation. (*accepted with revisions, 5 pages estimate*).

2. Mortensen N.P., Fennell T.R., Levine K., Black S.L., Snyder R.W., Novokhatny A., Poitras E., Harrington J., Pathmasiri W., **Sumner S.J.** Disposition of Intravenously or Orally Administered Silver Nanoparticles in Female and Pregnant Rats and the Effect on the Biochemical Profile in Urine. (*In Revision, 7* pages, *estimate*).

3. **Sumner S.**, McRitchie S, Perera, R. Relating Polycyclic Aromatic Hydrocarbon Exposure to Birth and Early Childhood outcomes via the Metabotype of Cord Blood. (*Submitted, 6 pages estimate*).

4. Saggi, S.J., Mercier, K., Gooding, J.R., Friedman, E., Vyas, U., Ranganathan, N., Rangnathan,P., McRitchie, S., **Sumner, S**. Metabolic profiling of a chronic kidney disease cohort reveals metabolic phenotype more likely to benefit from probiotic treatment. *(Submitted, 5 pages, estimate).*

5. Hassan B., Yooseph, S., Lee, E., Zaki A., Sherif, A., Laiyemo, A.O., Varma, S., Torralba, M., Dowd, S.E., Pathmasiri, W., **Sumner, S**, de Vos, W.M., Nelson, K.E., Zoetendal, E.G., Ashktorab, H. A Microbiomic and Metabolomics Analysis in African Americans with Colonic

Lesions Reveal Bacterial Markers with Potential Diagnostic Value. (*Submitted, 8 pages, estimate).*

6. Fennell T.R., Mortensen N.P., Levine K., Black S.L., Snyder R.W., Holland N.A., Poitras E., Harrington J., Pathmasiri W., Wingard C.J., **Sumner S.J**. Disposition of Intravenously or Orally Administered Silver Nanoparticles in Pregnant Dams and the Effect on the Biochemical Profile in Urine. *(Submitted, 6 pages, estimate).*

7. Johnson-Weaver BT, Mercier KA, McRitchie S, Pathmasiri W, **Sumner SJ**, Chan C, Germolec D, Kulis M, Burks AW, Staats HF. "Exposure to endotoxin and alum-adjuvanted vaccines does not enhance the induction of peanut allergy in mice." *(Submitted, 2 pages, estimate).*

8. McClenathan BM, Spooner CE, Choi YS, Stewart D, Pathmasiri W, McRitchie S, and **Sumner S**. Metabotypes of Subjects with Adverse Reactions Following Vaccination: A Pilot Study with NMR and Multivariate Analysis (*submitted, 4 pages, estimate).*

9. Merchant M., Brier, M., Gooding J. R., **Sumner, S**., Harrington, J., Burgess, J., McRitchie, S., Klein, J., & Himmelfarb, J. "Hemodialysis patient serum trace metals associate with dialysis incidence versus prevalence, gender, and response to erythropoiesis stimulating agents." *(In preparation, 6 pages, estimate).*

10. Sandhu R, Stewart DA, Kirk EL, Clark R, **Sumner S**, Troester MA. Correlated metabolomic genomic, and histologic phenotypes in breast cancer-adjacent tissue. *(In preparation, 8 pages, estimate).*

11. Mercier, K., Moreno, M., **Sumner, S**. Biomarkers of Behavior: Understanding the Metabolites and Pathways Involved in Mental Health Disorders. *(In preparation, 5 pages, estimate).*

12. Gooding, J.R., Burgess, J., McRitchie, S., Agarwal, S., Smoyer, W.E., and **Sumner, S.** Metabolism in Steroid-Sensitive and Steroid-Resistant Nephrotic Syndrome. *(In preparation, 5 pages, estimate).*

13. Leon LR, Stewart D, McRitchie S, Pathmasiri W, **Sumner S**, Dineen SM, Plamper ML, Audet GN. Indomethacin increases heat stroke severity in C57L/6J mice. *(In preparation, 11 pages, estimate).*

14. Kim K-S, Chou H, Funk DH, Pathmasiri W, Deese-Spruill J, **Sumner S**, Buchwalter D, Physiological responses to short-term temperature increase in larvae of the mayfly neocloeon triangulifer. *(In preparation, 8 pages, estimate*).

15. Petrovic S, McRitchie S, DuBose TD, Pathmasiri W, Burgess J, Xu J, Ma L, Ma J, Freedman, and **Sumner, S.** Urine metabolomics profile associates with early CKD and CKD progression. (*In preparation, 8 pages, estimate).*

16. Williamson BK, Hawkey NM, Blake DA, Frenkel JM, McDaniel KP, Davis JK, Satija C, Beazer A, Dhungana S, Carlson J, McRitchie S, **Sumner S**, and Ayyala, R. The effects of glaucoma drainage devices on oxygen tension, glycolytic metabolites, and metabolomics profile of aqueous humor in the rabbit" *(In preparation, 5 pages, estimate).*

Monographs and Reports

1. Tyl, R.W., Sloan, C.S., Hamby, B.H., Ehman, K.D., and **Sumner, S.** (2006). *Hershberger Background Review Document*. EPA contract number EP-W-06-026 Prepared by RTI International. Available at http://www.oecd.org/dataoecd/18/57/37880949.pdf. (201 pages).

2. **Sumner, S.C.J.** (2005). *Using Metabolomics/'Omics to Explore Species Differences in Metabolism*. Monograph presented at the National Academy of Sciences (NAS) Workshop on Toxicogenomics and Cross Species Comparisons, August 2004. National Academy of Sciences Press.

3. **Sumner, S.C.J.**, and Fennell, T.R. (2005). *Biomarkers, Omics, and Species Comparisons*. Monograph presented at the Board of Scientific Counselors (BOSC) Risk Assessment Workshop. National Academy of Sciences Press. February 2. (8 pages).

4. Collins, F. lead the development of this white paper. (2005). All subgroups and authors are listed at the link. *Design Considerations for a Potential United States Population-Based Cohort to Determine the Relationships among Genes, Environment, and Health: Recommendations of an Expert Panel*. **Susan Sumner** served on the Environmental Exposure Technology Development Sub-group. Available at http://www.genome.gov/Pages/About/OD/ReportsPublications/PotentialUSCohort.pdf. (52 pages).

5. **Sumner S.C.J.**, and Liu, G. (2004). Pathway linkage and data integration: Metabolomics holds key to intelligent discovery efforts. Pp. 127–128 *in Methods and Techniques in Drug Discovery*. Larchmont, NY: Mary Ann Liebert.

6. Colatsky, T., and **Sumner, S.C.J.** (2003). Metabolic profiling and biomarker discovery. *Current Opinions in Investigational Drugs 4*(3):1–3.

7. **Sumner, S.C.J.**, and Liu, G. (2002). Pathway linkage and data integration. *Genetics and Engineering News 22*(19). November 7.

8. **Sumner, S.C.J**., Cruzan, G., Johanson, G., Ghanayem, B., and Fennell, T.R. (2001). Metabolism of styrene in rats, mice, and humans. *CIIT Activities 21*:(3–4).

9. **Sumner, S**., T. Williams, B. Asgharian, and T. Fennell. 2001. *Acrylamide: Metabolism, Distribution, and Hemoglobin Adducts in Male F344 Rats and B6C3F1 Mice Following Inhalation Exposure and Distribution and Hemoglobin Adducts Following Dermal Application to F344 Rats*. TEGEWA.

10. **Sumner, S**., C. Williams, and T. Fennell. 1999. *Characterization of Urinary Metabolites of [1, 2, 3-* ^{13}*C]Acrylamide in Male F344 Rats Following Dermal Application or IP Injection*. Acrylamide Monomer Producers Association.

11. **Sumner, S**. 1999. *Urinary Metabolites of* ^{13}*C-styrene in Exposed Human Volunteers*. Styrene Information and Research Center.

12. **Sumner, S.C.J**., R.C. Cattley, D. Janszen, and T.R Fennell. 1999. *Blood Pharmacokinetics of Propylene Glycol Methyl Ether (PGME) and Propylene Glycol Methyl Ether Acetate (PGMEA) in Male F-344 Rats After Dermal Application*. Chemical Manufacturers Association.

13. **Sumner, S.C.J**., T.A. Moore, R.C. Cattley, and T.R. Fennell. 1999. *1,1,1,3,3,3-hexachloropropane: Metabolism and Distribution in Male and Female Sprague Dawley Rats Following Inhalation Exposure or IP Administration*. Vulcan Chemicals.

14. **Sumner, S.C.J**., B. Asgharian, C. Laethem, and T.R. Fennell. 1997. *Tertiary Amyl Methyl Ether (TAME): Metabolism and Distribution in Male and Female F344 Rats and CD-1 Mice after Single or Repeated Inhalation Exposures or Gavage Exposure*. American Petroleum Institute. Final Report.

15. **Sumner, S.C.J**., B. Asgharian, and T.R. Fennell. 1997. *Blood Pharmacokinetics of Tertiary Amyl Methyl Ether in Male and Female Rats and Mice Following Inhalation Exposure at 100, 500, and 2,500 ppm*. American Petroleum Institute. Final Report.

16. **Sumner, S.C.J**., B. Asgharian, T.A. Moore, and T.R. Fennell. 1997. *Tertiary Amyl Methyl Ether (TAME): Pilot Study for Metabolism, Distribution, and Pharmacokinetics in Male F344 Rats after a Single Nose-Only Inhalation Exposure*. American Petroleum Institute, Final Report.

17. **Sumner, S.C.J**., and Fennell, T.R. (1990). Nuclear magnetic resonance spectroscopy in metabolism studies. *CIIT Activities 10*(2):1–8.

Selected Conference Abstracts and Published Abstracts

1. Merchant, M., Gooding, J., **Sumner, S**., McRitchie, S., Harrington, J., Burgess, J.P., Rovin, B.H., Klein, J.B., and Himmelfarb, J. (2016). Hemodialysis Patient Plasma Trace Metals Associate with Dialysis Incidence Versus Prevalence, Gender and Response to Erythropoiesis Stimulating Agents. Accepted for ASN Kidney Week 2016 Nov 17 – 20, Chicago, IL.
2. Ongeri, E.M., Niyitegeka, J.M., Whitaker, C., McRitchie, S., Gooding, J, and **Sumner, S**. Meprin expression/activity impacts metabolite profiles in kidney tissue of mice with STZ induced type 1 diabetes. (2016). Accepted for ASN Kidney Week 2016 Nov 17 – 20, Chicago, IL.
3. Gooding, J., Niyitegeka, J-M V., Mcritchie, S., **Sumner, S**., Ongeri E.M., and Whitaker, C. Meprin beta-associated changes in serum and urine metabolite profiles of mice with streptozotocin (STZ) induced type 1 diabetes. Accepted for ASN Kidney Week 2016 Nov 17 – 20, Chicago, IL.
4. McClenathan B, Choi YS, Stewart D, Pathmasiri W, and **Sumner S**. (2016). Metabotypes of subjects with adverse reactions following vaccination: a pilot study. Oral presentation at the Military Health System Conference, August 2016, Florida.
5. McRitchie, S, Richardson, A, Pathmasiri, W, Perera, F, **Sumner, S.** (2016). Structural equation modeling: linking exposure to birth- and early life- health outcomes via the metabotype of cord blood." 2016 Metabolomics Society Meeting, Dublin, Ireland, June 2016.
6. Snyder, R. W., Mortensen, N. P., Pathmasiri, W. W., **Sumner, S. J**., & Fennell, T. R. (2016). Distribution, cellular localization, and metabolomics of multi-walled carbon nanotubes in female rats." Society of Toxicology 55th Annual Meeting and ToxExpo, New Orleans, LA., March, 2016.
7. Vickery B, Kulis M, Hamilton D, Stewart D, Pathmasiri W, McRitchie S, Burgess J, **Sumner S**, Burks AW (2016) NMR-based metabolomics analysis reproducibly identifies unique subject-specific profiles that change during peanut oral immunotherapy. American Academy of Allergy, Asthma & Immunology Annual Meeting, Los Angeles, CA, March, 2016.

8. Byrd, W., Carlson, J., McRitchie, S. **Sumner, S.J.** , Buse, J., Bencharit, S. (2016) Exploring Salivary Metabolomic Profiles of Well-Controlled and Poorly-Controlled Type 1 and Type 2 Diabetes. 2016 AADR/CADR Annual Meeting (March 16-19, 2016, Los Angeles, CA).
9. Gooding, J. R., Saggi, S. J., Friedman, E., Ranganathan, N., Rangnathan, P., Mercier, K., McRitchie, S. & **Sumner S.** (2015). Metabolomics of Chronic Kidney Disease in a Cohort of Patients Given Probiotics. Kidney Week, San Diego, CA, November 2015.
10. Gooding JR, Burgess J, McRitchie S, Agarwal S, Acuff Z, Smoyer WE, **Sumner S** (2015). Metabolism in Steroid-Sensitive and Steroid-Resistant Nephrotic Syndrome. Mayo Clinic Metabolomics Symposium, Rochester, MN. Awarded second-place in poster competition, October 2015.
11. Cabrera A, Dhungana S, Sheridan P, and **Sumner S** (2015). Metabolic profiling of anxiety prone HSV-latently infected obese mice. American Chemical Society. Duke University. Durham, NC., September 2015.
12. Moreno, M., Mercier, K., Deese-Spruill, Ward, T., and **Sumner, S**. (2015). A Metabolomics investigation on the impact of exposure to particulate matter from on Asthmatic Children. RTI Internship Showcase, August 2015.
13. Cabrera A, Dhungana S, Sheridan P, **Sumner S** (2015). Metabolomic Profiling of Anxiety Prone HSV-Latently Infected Obese Mice. RTI Internship Showcase, August 2015
14. Harris R, Dhungana S, **Sumner S**. (2015) UPLS-MS Broad Spectrum Lipidomics Platform Development." RTI Internship Showcase, August 2015.
15. **Sumner, S. J.**, Richardson, A. S., McRitchie, S. L., Pathmasiri, W. W., & Perera, F. (2015) *Relating exposure to health outcomes via the metabotype of cord blood. A problem for structural equation modeling*. Poster presented at Advancing Analysis of Xenobiotics in Environmental and Biological Media, U.S. Environmental Protection Agency, Research Triangle Park, NC, August 2015.
16. Deese-Spruill, J. Y., Carlson, J. E., Mercier, K. A., Monero, M., Devlin, R., Ward, T., and **Sumner, S. J.** (2015). *Particulate matter exposure and perturbations in the metabolome*. Poster presented at Advancing Analysis of Xenobiotics in Environmental and Biological Media, U.S. Environmental Protection Agency, Research Triangle Park, NC, August 2015.
17. Dhungana, S., & **Sumner, S. J.** (2015). *Profiling endocannabinoids and cannabinoid receptor agonist/antagonist fatty acid amides using UPLC-TOF ion mobility mass spectrometry*. Poster presented at Advancing Analysis of Xenobiotics in Environmental and Biological Media, U.S. Environmental Protection Agency, Research Triangle Park, NC, August 2015.
18. Fennell, T. R., Snyder, R. W., Pathmasiri, W. W., McRitchie, S. L., Burgess, J. P., & **Sumner, S. J**. (2015). *Metabolomics in the assessment of prior in utero exposure*. Poster presented at Advancing Analysis of Xenobiotics in Environmental and Biological Media, U.S. Environmental Protection Agency, Research Triangle Park, NC, August 2015.
19. Pathmasiri, W. W., Laine, J. E., Bailey, K. A., Olshan, A. F., Smeester, L., Drobna, Z., … **Sumner, S. J**., et al. (2015). *A metabolomic signature of in utero inorganic arsenic exposure in fetal cord serum*. Poster presented at Advancing Analysis of Xenobiotics in Environmental and Biological Media, U.S. Environmental Protection Agency, Research Triangle Park, NC, August 2015.
20. Li, J., Stewart, P., Fisher, K., Dhungana, S., Stewart, D. A., **Sumner, S. J.,** et al. (2015). *Proteo-metabolomic dissection of small cell lung cancer using activity based protein profiling and*

metabolomics profiling. Presented at The Metabolomics Society Meeting, San Francisco, CA, June 2015.

21. Cox, L., Pathmasiri, W. W., McRitchie, S. L., Sohn, J., Robine, N., **Sumner, S. J**., et al. (2015). *Systemic metabolic impact of early-life microbiota disruption*. Presented at The Metabolomics Society Meeting, San Francisco, CA, June 2015.
22. Weiss, E. R., Dhungana, S., Osawa, S., McRitchie, S. L., & **Sumner, S. J**. (2015). *Metabolomic profiling of early events in retinal degeneration*. Presented at The Metabolomics Society Meeting, San Francisco, CA, June 2015.
23. Petrovic, S., McRitchie, S. L., DuBose, Jr., T., Pathmasiri, W. W., Burgess, J. P., Xu, J., **Sumner, S. J**. (2015). *Urine Metabolomics Profile in Early CKD*. Oral and poster presentations at The Metabolomics Society Meeting, San Francisco, CA, June 2015.
24. Brophy, P., Mercier, K. A., McRitchie, S. L., Pathmasiri, W. W**., Sumner, S. J**., Koralkar, R., et al. (2015). *Metabolomics profiling of renal development and acute kidney injury in premature infants*. Presented at The Metabolomics Society Meeting, San Francisco, CA, June 2015.
25. Stewart, D. A., Winnike, J., McRitchie, S. L., Pathmasiri, W. W., & **Sumner, S. J**. (2015). *Triple negative breast cancer biomarker identification for drug development*. Poster presented at The Metabolomics Society Meeting, San Francisco, CA, June 2015.
26. Pathmasiri, W. W., Loeser, R., **Sumner, S. J**., McRitchie, S. L., Beavers, D., Saxena, P., et al. (2015). *Correlation of urinary metabolites with radiographic progression of knee osteoarthritis in overweight and obese adults*. Poster presented at The Metabolomics Society Meeting, San Francisco, CA, June 2015.
27. Wiernek, S., Mercier, K. A., Pathmasiri, W. W., McRitchie, S. L., **Sumner, S. J**., & Dai, X. (2015). *Global metabolomic profiling of endothelial cell response to inorganic phosphate*. Poster presented at The Metabolomics Society Meeting, San Francisco, CA, June 2015.
28. Dhungana, S., & **Sumner, S. J.** (2015). *Profiling endocannabinoids and cannabinoid receptor agonist/antagonist fatty acid amides using UPLC-TOF ion mobility mass spectrometry*. Poster presented at The Metabolomics Society Meeting, San Francisco, CA, June 2015.
29. Brophy, P., Mercier, K. A., Novokhatny, A., McRitchie, S. L., Pathmasiri, W. W., Burgess, J. P., **Sumner, S. J**., et al. (2015). *Metabolomics profiling of renal development and acute kidney injury in premature infants.* Presented at Metabolomics 2015, Burlingame, CA, June 2015.
30. Wang, H., Liang, S., Wang, M., Gao, J., Sun, C., Wang, J., **Sumner, S. J**., et al. (2015). *Metabolomics study of autism for biomarker discovery in Han Chinese population*. Poster presented at Society of Biological Psychiatry's 70th Annual Scientific Meeting entitled Stress, Emotion, Neurodevelopment, and Psychopathology, Toronto, Canada, May 2015.
31. Stewart, D. A., Winnike, J., McRitchie, S. L., Pathmasiri, W. W., & **Sumner, S. J.** (2015). *Triple negative breast cancer: Metabolomics and flux analysis to identify targets for drug development*. Poster presented at the American Association for Cancer Research Annual Meeting, Philadelphia, PA, April, 2015.
32. Kenley, S., Whitaker, C., Niyitegeka, J., Sedighi, R., Gooding, J., McRitchie, S., **Sumner, S**., & Ongeri, E. M. (2015). Meprin deficiency associated with higher levels of neutrophil gelatinase associated lipocalin (NGAL) and kidney injury molecule (KIM-1) in mice with streptozotocin induced type 1 diabetes. Experimental Biology, San Diego, CA, April 2015.

33. Appt, S., Dhungana, S., McRitchie, S. L., & **Sumner, S. J.** (2014). *Ovarian metabolomic profiles differ between monkeys consuming prudent and Western diets*. Poster presented at North American Menopause Society (NAMS) 25th Annual Meeting, Washington, DC, October 2014.
34. Raymer, J. H., Michael, L. C., **Sumner, S. J**., Studabaker, W. B., Deese-Spruill, J. Y., Ward, T., Noonan, C., & Devlin, R. (2014). *Environmental exposures to PM and resultant metabolomic pertubations in humans*. Poster presented at the Annual Conference of the International Society of Exposure Science (ISES 2014), Cincinnati, OH, October 2014.
35. Mortensen, N. P., Stewart, D. A., Pathmasiri, W. W., Mercier, K. A., McRitchie, S. L., Cavallo, T., **Sumner, S. J.** (2014). *Metabolomics and darkfield microscopy of mammalian cells from microfluidic and transwell systems*. Poster presented at NIH Common Fund Metabolomics Consortium Meeting, Research Triangle Park, NC, October, 2014.
36. Burgess, J. P., Cavallo, T., Pathmasiri, W. W., Mercier, K. A., McRitchie, S. L., Novokhatny, A., & **Sumner, S. J.** (2014). *Metabotyping of ABO blood groups*. Poster presented at NIH Common Fund Metabolomics Consortium Meeting, Research Triangle Park, NC, October 2014.
37. **Sumner, S. J**., McRitchie, S. L., Pathmasiri, W. W., & Dhungana, S. (2014). *Metabolomics in the assessment of exposure and health outcomes*. Poster presented at 10th Annual International Conference of the Metabolomics Society, Tsuruoka, Japan, June 2014.
38. Weiss, E. R., Osawa, S., Dhungana, S., McRitchie, S. L., **Sumner, S. J.** (2014). *Metabolic differences between light- and dark-adapted mouse retinas*. Poster presented at The Association for Research in Vision and Ophthalmology (ARVO), Orlando, FL, May, 2014.
39. Novokhatny, A., **Sumner, S. J.**, Snyder, R. W., Lewin, A. H., Pathmasiri, W. W., Brown, J. M., et al. (2013). *A distribution and metabolomics investigation of the impact of fullerene C60 exposure in mice fed high fat diets and mice fed diets normal in fat.* Poster presented at North Carolina Section of the American Chemical Society Sectional Conference, North Carolina State University, Raleigh, NC, November 2013.
40. Dhungana, S., Thomas, B. F., & **Sumner, S. J.** (2013). *Comparison and refinement of UPLC-MS based broad spectrum metabolomics methods*. Poster presented at the American Society for Mass Spectrometry's 61st Conference on Mass Spectrometry and Allied Topics, Minneapolis, MN, July 2013.
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Selected Invited Presentations

1. *Harmonization of Untargeted Analysis Cores for the Children' Health Exposure Analysis Resource (CHEAR) Hub.* International Society of Exposure Sciences. Utrecht, Netherlands. October 10, 2016.
2. *Structure Equation Modelling to Link Exposure to Health Outcomes via the Metaboytpe of Cord Blood.* International Society of Exposure Sciences. Utrecht, Netherlands. October 10, 2016.
3. *Metabolomics in Women's Health*, University of California at Davis, September, 7, 2016.
4. *Metabolomics in Maternal and Child Health*, Presented at National Institute of Standards and Technology, Charleston, South Carolina, August 1, 2016.
5. *Experiences as a Regional Metabolomics Center.* 4th Annual Workshop on Metabolomics, University of Alabama Birmingham, July 17-21, 2016.
6. *Early biomarkers to predict risk of third trimester placental abruption*. June 30, 2016 Metabolomics Society Meeting, Dublin, Ireland.
7. *Metabolomics in Nutrition Research.* Presented at the Nutrigenomics, Nutrigenomics, and Precision Nutrition Workshop. May 22-26, 2016.
8. *Metabolomics in Nutritional Research, and Implications in Blood Type Research*. Presented at American Society for Nutrition (ASN) Experimental Biology, Promise of Metabolomics for Advancing Nutrition Research, San Diego, CA. April 6, 2016.
9. *Biomarkers in Maternal and Child Health*. Presented at New York University Medical Center, New York, NY. January 29, 2016.
10. *Metabolomics for Pediatric Biomarkers*. J. Yaffe Memorial Lecture Series, *Eunice Kennedy Shriver* National Institute of Child Health and Human Development. Bethesda, MD. January 16, 2016.

11. *Metabolomics in Maternal and Child Health*. Presented at the University of Michigan Medical School, Ann Arbor, MI. December 9, 2015.
12. *Metabolomics to Reveal Markers of the Environmental Influence of Disease in Pregnancy and Early in Life.* Presented at Emory University, Atlanta, GA. October 13, 2015.
13. *Metabolomics as a Tool for Characterizing the Exposome.* Presented at the National Academy of Sciences, Washington, DC. May 28–29, 2015.
14. *New Horizons. Metabolomics of Kidney Disease*. Presented at the Emerging Trends in Dialysis Care. SUNY DownState Medical Center, NY, May 8, 2015.
15. *Metabolomics in Epidemiology*. Presented to the School of Veterinary Medicine, North Carolina State University, Raleigh, NC. March 2015.
16. *Why Biomarkers Matter*. Presented at Cancer Prevention in India: Catalyzing Action and Enhancing Implementation, New Delhi, India. February 20, 2015.
17. *Translational Sciences*. Presented to the Department of Biology, North Carolina AT&T State University, Greensboro, NC. January 30, 2015.
18. *Metabolomics in Environmental Sciences*. Presented at the Nicholas School of the Environment, Duke University, Durham, NC. January 28, 2015.
19. *Metabolomics to Provide Biomarkers and Mechanistic Insights*. INDO-US Symposium: Mass Spectrometry Based Metabolomics in Disease Biology, Trivandrum, Kerala, India. January 23–24, 2014.
20. *Metabolomics in Toxicology*. Presented to the American Chemical Society, Indianapolis, IN. October 10, 2013.
21. *Metabolomics at RTI*. Presented at the Metabolomics Society Meeting, Glasgow, Scotland. July 2013.
22. *Metabolomics in Urology*. Presented at the NIH Workshop at Lister Hill, Bethesda, MD. February 2013.
23. *Personalized Medicine and Environmental Omics*. Presented at the Environmental Omics Conference, Guangzhou, Guangdong Province. November 8–12, 2011.
24. *Metabolomics for the Midwestern Pediatric Nephrology Consortium*. Presented in Chicago, IL. November 11, 2012.
25. *Metabolomics in Epidemiology*. Presented at the University of North Carolina at Chapel Hill, Chapel Hill, NC. November 2012.
26. *Metabolomics in Pharmacology*. Presented at the Duke University, Durham, NC. November 2012.
27. *Metabolomics in Clinical Research.* Presented at Wake Forest University, Greensboro, NC. October 2012.
28. *Personalized medicine and environmental OMICS. Session E2*. Presented at 2011 International Conference on Environmental OMICS (ICEO), November 11, 2011, Guangzhou, China.
29. *Biomarkers in Personalized Medicine: Applications of Metabolomics to Provide Biomarkers for the Treatment of Obesity, Liver Injury, and Reproduction and Development Outcomes*. Presented to the American Association for the Advancement of Sciences, Washington, DC. February 19, 2011.

30. *Applications of Metabolomics*. National Toxicology Program. Presented at NIEHS, RTP, NC. June 16, 2010.
31. Panelist, Personalized Medicine Symposium, sponsored by RTI and the North Carolina Biotechnology Center (NCBC), Sheraton Imperial Hotel and Convention Center, RTP, NC. June 15, 2010.
32. *Emerging Technologies in Personalized Medicine*. Presented at the Brody School of Medicine, East Carolina University, Greenville, NC. February 4, 2010.
33. *Metabolomics and Proteomics: Early and Sensitive Markers for Personalized Medicine*. Presented at the RTI Fellows' Symposium, Friday Center, Chapel Hill, NC. November 2, 2009.
34. *Incorporation of 'Omics in the Study of Reproduction and Development*. Presented to SOT, Baltimore, MD. March 2009.
35. *Metabolomics in Drug Discovery and Drug Development*. Presented to the Eastern Analytical Society (EAS), Somerset, NJ. November 17–20, 2008.
36. *Metabolomics in the Study of Reproduction and Development*. Presented at the Women's Health Initiative, Friday Center, Chapel Hill, NC. April 2, 2008.
37. *Metabolomics: Application to the Study of Phthalates in Reproduction and Development*. Presented at the SOT Meeting, Seattle, WA. March 17, 2008.
38. *Metabolomics: Applications to Pediatrics Health*. Presented at the 5th Annual Pediatric Healthy Weight Conference, Greenville, NC. March 6, 2008.
39. *Biomarkers in Translational Medicine*. Presented at the Innovations and Technologies for India's Public Health System, New Delhi, India. November 1–2, 2007.
40. *Metabolomics in the Study of Endocrine Disruption*. Presented to EPA's Endocrine Disrupting Chemical Discussion Group, EPA, RTP, NC. October 10, 2007.
41. *Developing Markers Informative of Adverse Response from Drugs or Chemicals*. Presented at the Advances in Metabolite Profiling Conference, London, England. October 17–19, 2006.
42. *Metabolomics in Reproductive Toxicology*. Presented at the Science and Engineering Fellows Symposium (Sponsor: Rochelle Tyl), RTI, RTP, NC. September 2006.
43. *Metabolomics and biomarkers*. New Jersey Drug Metabolism Group Symposium, Somerset, NJ. October 2005.
44. *Metabolomics: Promises and Realities*. Presented at the Fox Chase Cancer Research Center, Buckingham, PA. April 2005.
45. *Metabolomics, Biomarkers, and Cross Species Extrapolation*. Presented at the Board of Scientific Councilors EPA Workshop, National Academy of Sciences, Washington, DC. February 2005.
46. *Cross-species Extrapolation of Toxicogenomics Data*. Presented at the Board of Scientific Councilors' EPA Workshop, National Academy of Sciences Workshop, Washington, DC. August 2004.
47. *Metabolomics: Data Analysis and Pathway Mapping*. Presented at the NIH ADME/Toxicity Summit, NIH Lister Hill, Bethesda, MD. June 2004.
48. *From Metabolites to the Metabolome: Chemistry and Biochemistry Symposium.* Presented at the University of North Carolina at Wilmington, Wilmington, NC. January 29, 2004.

49. *Metabolomics and Pathway Mapping*: Triangle Array Users Group. Presented at NCBC, RTP, Park, NC. November 2003.
50. *Metabolomics: Processes and Approaches*. Presented to the NIEHS ToxPath Working Group, NIEHS, RTP, NC. June 2003.
51. *Metabolomics: From Genes to Cells to Systems.* Presented to the NIEHS International Workshop on Metabonomics, NIEHS, RTP, NC. May 2003.
52. Lecturer, Continuing Education Course, *Applications of NMR Spectroscopy in Toxicology*. Presented to SOT. March 1993.

Teaching Activities

Workshops, Webinars, Seminars, Web-based training

As the Principal Investigator of the NIH Common Fund Eastern Regional Comprehensive Metabolomics Research Core (NIH C-F ERCMRC), I have had the responsibility for developing and overseeing the activities of the promotion and outreach core.

The promotion and outreach activities that I have lead included holding workshops and seminars to engage basic, applied, and clinical researchers in using metabolomics to determine biomarkers and/or gain insights into biological mechanisms, traveling to Universities and Conferences to showcase metabolomics studies (see invited presentations), and developing hands on and web-based learning tools.

Workshops held by the NIH C-F ERCMRC: I have held five workshops (two in 2013 and 2014; one workshop in 2015) which were each attended by approximately 80-100 researchers interested in learning more about metabolomics and how to apply it in their research areas. These workshops include seminars and break-out sessions for participants to discuss how metabolomics may fit in their research.

Workshop Participation: In the past three years, I have presented at several workshops, including a) the 2016 Nutrigenomics, Nutrigenomics, and Precision Nutrition Workshop held at the UNC-NRI, b) the 2014 workshop at the Mayo Clinic, and c) the 2015 new trends in dialysis workshop at SUNY Downstate.

Classroom Settings and Seminars: During the past few years (as indicated under Invited Presentations), I have given classroom presentations or seminars at Duke University, NCSU, UNC-CH, NC A&T, Wake Forest University, University of Michigan, the Mayo Clinic, Emory University, University of Alabama Birmingham, NYU Medical Center, DownState Medical Center, and UC Davis that were attended by undergraduate and graduate students, and staff and faculty interested in the area of metabolomics, and how to apply these approaches in their research.

Skype Classes: I have developed materials that have been used in classes (via Skype) with students at the University of Alabama Birmingham, University of Guatemala, and Africa.

Webinars: I have participated in the development of materials for early career staff to present at NIH C-F metabolomics program webinars, and I recently presented a Webinar on Pediatric Biomarkers as part of the NICHD J. Yaffe Memorial Lecture Series.

Web-based Training: Over the past several years, I have worked with UNC-CH's Dr. Martin Kohlmeier on his R25 award to develop an online learning platform that introduces clinicians and researchers to metabolomics

Hands on Training: Early in 2012, I developed "Metabolomics 101" course material that has been has been refined and used many times through the past 4 years to provide basic training on the acquisition and analysis of metabolomics data. Over the past few years, this material has been used to teach a week long training class at the University of Alabama Birmingham as part of the NIH C-F Metabolomics

Training Program lead by Dr. Stephen Barnes. This includes information on study design, sample collection and preparation, data acquisition, and data analysis- including a hands on data analysis tutorial.

Metabolomics Workbench: I collaborated with Dr. Shankar Subramanian (University of California, San Diego) and the NIH C-F metabolomics consortium to create Metabolomics Workbench (www.metabolomicsworkbench.org). Metabolomics Workbench contains raw and processed data, data analysis tools, tutorials, and a wealth of information on metabolomics.

Students and Mentoring Activities as the PI/Director of the NIH C-F ERMRC

Students, postdoctoral fellows, early career scientists, senior scientists, and scholars trained in various aspects of metabolomics between 2005 and 2016 in my laboratory.

Name and degree when trained	Field	Start Year	Metabolomics Training	Position at time of training	Current Position
Aurora Carbera, BS	Chemistry	2015	UPLC-TOF-MS	Intern Meredith College	Graduate School Duke
Kelly Mercier, PhD	Chemistry	2015	NMR	Early Career Trainee	RTI Staff
Maria Moreno, BS	Biochemistry	2015	NMR	Intern	RTI Staff
Claudia Gunsch, PhD	Environmental Sciences	2015	General	Visiting Scholar Duke University	Faculty Duke University
Ellen Weiss, PhD	Biochemistry	2015	General	Visiting Scholar UNC-CH	Faculty UNC-CH
Rose Ewald	Nutrition	2015	Literature Reviews	Intern UNC-CG	Graduate School UNC-CH
[1]Jessica Gooding, PhD	Chemistry	2015	UPLC-TOF-MS, NMR	NIH Common Fund K-Awardee	RTI Staff
Yuan Li, PhD	Natural Products	2015	UPLC-TOF-MS	Postdoctoral Fellow	Postdoctoral Fellow
Bizu Gelaye, PhD	Epidemiology	2014	General	Postdoctoral Fellow Harvard	Research Scientist, Harvard
Tammy Cavallo, BS	Biology	2014	GC-TOF-MS	Intern NCSU	RTI Staff
Courtney Whitaker	Chemistry	2014	LC-MS	Undergraduate UNC-CH	RTI Staff
Ninell Mortensen, PhD	Biomed. Eng.	2013	Metabolic Pathways	Early Career Trainee	RTI Staff
[2]Aastha Ghimere	Biology	2013	UPLC-TOF-MS	Undergraduate UNC-CH	Graduate School Univ. Edinburgh
Darya Cheng, BS	Chemistry	2013	UPLC-TOF-MS	Intern Duke University	Graduate School UCLA
[2]Jon Brodish	Biology	2013	UPLC-TOF-MS	Intern UNC-CH	Medical School (TBD)
Suraj Dhungana, PhD	Chemistry	2012	UPLC-TOF-MS	Early Career Trainee	RTI Staff
Delisha Stewart, PhD	Molecular Biology	2012	UPLC-TOF-MS and NMR	Postdoctoral Fellow	RTI Staff
[2]Ranjan Banergee	Biology	2011	NMR	Intern UNC-CH	Medical School UNC-CH
[3]David Szabo, PhD	Env. Sci.	2011	General	Graduate Student	RJ Renoylds
Susan McRitchie, MS	Biostatistics	2011	Metabolomics Analysis	Biostatistics/Social Sciences	RTI Staff
[4]Andrew Novokhatny	Biochemistry	2010	NMR	Intern (NCSU)	Graduate School UNC-CH

Wimal Pathmasiri, PhD	Biochemistry	2009	NMR	Postdoctoral Fellow	RTI Staff
Rodney Snyder, MS	Nutrition	2005	NMR	RTI Chemist	RTI Staff
Jocelin Deese-Spruill, BS	Chemistry	2005	GC-MS	RTI Chemist	RTI Staff

[1] Jessica Gooding is completing a NIH C-F K-award in my laboratory.
[2] These students completed undergraduate coursework at UNC-CH while interning in my laboratory.
[3] David Szabo completed elements of his PhD dissertation- including manuscript from research conducted in my laboratory.
[4] Andrew Novokhatny completed elements of his Master's Degree in Health Information.

Students and Mentoring Activities while at CIIT

While on staff at the Chemical Industry Institute of Toxicology (1989-2001), I had the opportunity to mentor a number of technical staff, students, and postdoctoral fellows.

2000-2002. Kenneth Cutler, PhD, Director of Project Seed. I supported Dr. Kenneth Cutler in his effort to grow a program to support economically disadvantaged high school students to pursue careers in science. I worked with Dr. Cutler to establish an office for Project Seed with administrative support to the program. Project Seed is affiliated with the American Chemical Society (ACS), and I provided oversight for Project Seed in my capacity as Chair of NCACS in 2001 and Past Chair 2002.

1998-1999 Amy Collins, PhD. While a graduate student in the Department of Mathematics at NCSU, Amy conducted her research at CIIT, and with me and Dr. Michelle Medinsky to develop a PB-PK model for butadiene, resulting in one manuscript as part of her dissertation thesis.

1998. Annsofi Nihlén, PhD. Ansofi Nihlén conducted her dissertation research with Dr. Gunnar of the *Institute of Environmental Medicine at Karolinska Institute, Sweden.* A component of Ansofi's research involved analysis of metabolites excreted in urine from participants exposed to methyl tertiary butyl ether. Ansofi's work in my laboratory as a visiting scholar in 1998, resulted in a joint publication and served as one of the three publications to support her dissertation research. She joined the faculty at The Department of Toxicology and Chemistry, National Institute for Working Life.

1996-1997. Lena Selveraj, PhD. Dr. Lena Selveraj conducted a postdoctoral fellowship in my laboratory at CIIT (96-97), working in the area of metabolite and DNA adduct characterization, resulting in two publications. Dr. Selveraj was the co-founder of a startup biotechnology company in Texas in the late 90s where she provided oversight of lab based research and structural characterization.

1995-1997. Sara Nauhaus, MS. While a graduate student in the Department of Chemistry at Duke University, Sara Nauhaus conducted her Master's Thesis research in my laboratory at CIIT (1995-1997). Sara developed analytical skills and coordinated and conducted animal research investigations. Sara is now a Clinical Team Manager at Chiltern.

1992-1994. J. Mark Yates, PhD. While a graduate student in the Department of Chemistry at North Carolina State University, Jay Mark Yates conducted his dissertation research (1992-1994) working in my laboratory at CIIT. Mark's dissertation research involved the investigation of the DNA adduct formation of cyanoethylene oxide, resulting in two publications in *Carcinogenesis*. He served on the faculty at Campbell University and as a Validation Specialist.

1989-2000. Through the CIIT visiting scholar program, Dr. Peter Boogard (Senior Toxicologist, Shell International, Netherlands) worked with my group to investigation metabolism and DNA adduct formation of butadiene (BD), resulting in four publications and the generation of data used in assessment of risks from exposure to BD. Dr. Siv Osterman-Golkar (Karolinska Institute) was also a visiting scholar

at CIIT, and worked with me to learn the use of carbon-13 labels in metabolism investigations, resulting in several joint publications. Additional postdoctoral fellows whom I mentored in the general area of metabolism, and specifically related to incorporating labels for quantitative interpretations of metabolism across species and development of physiologically based pharmacokinetic models included Dr. Carl Brown, Dr. Kannon Krishnan, and Dr. David Clark.

CONTRACTS AND GRANTS RECEIVED

Active

0212645-S1 (Wiley, PI) 9/1/2016-8/31/2017
National Institute of Drug Abuse $100,000 dollar supplement to parent grant
Sex Differences in Cannabinoid Dependence and Analgesia
The grant will examine sex differences in and hormonal modulation of the pharmacological effects of cannabinoids, including investigation of pharmacokinetic differences.
Role: Co-I to conduct metabolomics analysis

5P01ED022832-03 (Karagas, PI) 9/1/2016-8/31/2017 0.3 calendar mo/year
Dartmouth's Children's Environmental Health and Disease Prevention Center $100,000 dollar supplement to parent grant
The aim of this supplement is to discover biomarkers that capture the functional effects of infant dietary factors on the microbiota and to gain insights into mechanisms associated with infection in infancy.
Role: Co-Investigator. Metabolomics analysis

U2CES026544-01 (Fennell, PI) 9/28/2015–08/30/2019 0.5 calendar mo/year
National Institute of Environmental Health Sciences $1.126 M total
RTI CHEAR Exposure Assessment Hub
The goal of this Hub is to conduct analysis of biospecimens for markers of exposure and response.
Role: Susan Sumner is the PI of the Untargeted Analysis Core

P30ES02518 (Smart, NCSU) 3/15/2015-3/15/2020 0.6 cal mo/year
NIEHS Center for Human Health and Environment $24,120
Co-I: Sumner advisor to the CHHE for analytical analysis

UL1TR00111: (Tim Cary and John Buse, UNC-CH) 10/2013-10/2018 0.6 cal mo/year
NCATS (North Carolina Translational and Clinical Sciences Institute") $250,000
Role: Director of the NCTraCS Metabolomics Core: UNC-CH

1UMDK10086601 (Smoyer, PI) 9/16/2013-5/31/2018 0.55 calendar mo/year
NIDDK: sub to Nationwide Children's Hospital $74,294
Biorepository for Pediatric Glomerular Disease
Role: Sumner, co-investigator to provide advice on sample collection and storage

HHSN268201300021C (Seltzman, PI) 7/15/13-7/14/18 0.2 cal mo/year
NIH Common Fund: NHLBI $19,214/year
Role: Sumner, co-I to provide advice on metabolite synthesis

1U24DK097193-01 (Sumner, PI) 9/4/2012-8/31/2017 3.61 calendar mo/year
NIH Common Fund: NIDDK $5,396,877 annual
NIH Eastern Regional Comprehensive Metabolomics Resource Core at RTI International (RTI RCMRC)
The major goals of this project are conduct metabolomics investigations in clinical and translational research.
Role: PI

1 U19 ES019525-01 (Fennell, PI) 9/28/2010–04/30/2017 0.5 calendar mo/year
NIEHS $6.3 m total
C60, MWCNTs and the Influence on Cardiovascular, Reproductive, and Developmental Processes
The goal of this center is to develop data on the disposition and effects of exposure to carbon nanoparticles and integrate th
data obtained in a pharmacokinetic/pharmacodynamic framework that can be used in human risk assessment.
Role: Sumner: PI of Project II Center R01

Fall 2016 Notice of Awards Received

Number pending. Richard Loeser, UNC-CH, PI Award Noticed Received 10/03/2016
Arthritis Foundation ~$22,000 in metabolomics analysis for years 2 and 3
Role: Metabolomics Analysis

Number pending. Karagas, Dartmouth, PI 9/1/2017-9/1/2024 0.5 cal mo/year
National Institute of Environmental Health Sciences $868,288
Environmental Influences of Child Health Outcomes (ECHO) Pediatrics Cohort
Dartmouth Pediatric ECHO Cohort
Role: Director Metabolomics

Number pending. Trasande, NYU School of Medicine 9/1/2017-9/1/2024 0.6 cal mo/year 1
National Institute of Environmental Health Sciences $3,392,483 1.2 cal mo/years 2-7
Environmental Influences of Child Health Outcomes (ECHO) Pediatrics Cohort
NYU Pediatric Obesity, Metabolism and Kidney Cohort Center
Role: Co-investigator - direct the Metabolomics analysis

1U01 ES027254 01 Sumner/Mortensen/Fennell (MPI) 9/2/2016-9/1/2012 1.2 cal mo/year
National Institute of Environmental Health Sciences $2,800,000
Early Life Exposure to Nanoparticles and Health Risks
Role: PI of Specific Aim 3- Biomarker Analysis

U2C ES026544 01S1 Fennell, PI 9/1/2016-8/31/2017 1.8 cal mo/year
National Institute of Environmental Health Sciences $1,485,542 Total
Exposure Analysis Services for the Environmental Influences on Children's Health Outcomes (ECHO) Program (Admin Supp)
The goal of this project is to provide support for the ECHO program to conduct untargeted and targeted analyses for the determination exposure markers in samples from children's health studies.
Role: Director of the Untargeted Analysis Core

Pending with Exceptional Score and at the Just In Time Phase

Sumner, PI 9/01/2016-8/30/2022 0.36 cal mo in year 1
NIH $16,846,319 total 3.85 cal mo/years 2-6

Molecular Transducers of Physical Activity Metabolomics and Proteomics Chemical Analysis Sites (U24)
Investigating the impact of physical activity on the human metabolome may provide insights for the development of intervention strategies- personalized training regimens, identification of targets for nutrition supplementation, or drug development.
Role: Director

Past Support: Government and Commercial

1U2C ES026544 Sumner, PI 2015-2016
NIEHS $298,130
Untargeted Analysis Resource Core (UARC) for the Children's Health Exposure Analysis Resource.
Role: PI of the UARC.

R25 GM103802 Kohlmeier, PI, UNC-CH 2012-2016
NIGMS ~$500K total and ~$24K per year Sumner
Online learning platform: introducing clinicians and researchers to metabolomics.
Role: provide advice, interviews, and tutorials on metabolomics.

1U19 ES019525 Sumner, PI 2010-2015
NIEHS ~ $3.5 million
Project 2 of U19. Pharmacokinetics and Pharmacodynamics of C60 and MWCNTS in Rats and Mice.
Role: PI of the RO1- Project 2 of U19 nanoparticle center.

Consultant: Sumner, PI 5/2009-5/2010
NIH $60K
Study Design, Safety, and Toxicology Consultant to the National Institutes of Health.
Role: Provide consultation for protocol and SOP development.

Metabolomics of Soy and Casein Diets (Kaplan, PI) 2008
NIH $10K
Role: Sumner: Metabolomics subcontract to grant held at Wake Forest University.

Confidential Client: Pharmacokinetic Investigations of Acrylonitrile (AN).
Sumner: Co-investigator. Fennell (PI). 08/2008 – 02/2009.
Performed investigations of the pharmacokinetics of AN in rats.

N66001-05-D Naval Health Research Center Biospecimen Data Collection Design and Methodology Considerations – The Millennium Cohort Study (2007).
N66001-05-D- 2500/0009; $100,000; Dr. Michael Schwerin, RTI Contract Leader
Role: Dr. Sumner contributed to a framework for merging new markers in the MilCohort Study and recommendations for pilot projects. The purpose of this project was to develop recommendations for the MilCohort Study related to biospecimen collection procedures, potential use in biomarker development, and description of pilot studies that could be conducted using serum from existing repositories or using additional biospecimens.

Confidential Client. (~$70K) Sumner Co-investigator. Fennell (PI). 3/2006 - 9/2006. This study investigated *the identity of colored metabolites of a drug candidate in rat urine.*

N01-ES-65554: NIEHS 12/01/05–11/30/2010 + renewal 10/2010-9/2015
National Toxicology Program (NTP) Chemistry Support Services $880,000 + $2,586.947

PI: Reshan Fernando
Role: Sumner served as Leader for metabolomics investigations, including:
1.Establishing a link between interaction of xenobiotics with the nuclear receptor, RORα and TAK1, their effects on gene expression, physiological processes (including metabolism), and disease.
2.Metabolomics Studies on Mouse Serum after HBCD Exposure.
3.Metabolomics Investigation of Resveratrol in Exposed Rats.

R21GM075903 Sumner, PI 9/01/2005-7/31/2010
NIGMS: NIH Roadmap $1.8 million
Metabolomics: Markers of Drug Induced Liver Injury
Role: PI

Confidential Client. Metabolism and pharmacokinetic studies on diisopropylether, tertiary butyl alcohol and ethyl tertiary butyl ether. (~$1 million) Sumner Co-investigator. Fennell (PI). 11/2004 - 3/2007.

EP-D-04-068 U.S. EPA Human and Ecological Exposure Monitoring Research (2003–2005)
RTI Subcontract to Battelle, Dr. James Raymer, RTI Leader for Subcontract.
Provided support to the EPA Office of Research and Development National Exposure Research Laboratory (ORD/NERL) Role: Dr. Sumner made recommendations regarding the use of existing samples from NHANES, NHEXAS, and CTEEP for the development of biomarkers of exposure, effect, or susceptibility with considerations of incorporation of these markers in the assessment of human health risks from exposure to environmental contaminants. This project included the development of a PB-PK model using data derived from the NHANES studies.

Confidential Client: Metabolism and adducts of acrylamide (AM):
Sumner Co-investigator. Fennell (PI). 8/2002 - 12/2006.
Performed investigations of the metabolism and pharmacokinetics and adduct formation by AM in rats and humans.
HHSN291200445524C NIEHS Phase I/Phase II Small Business Innovated Research Award.
NIEHS: Sumner PI. Awarded while employed at Paradigm Genetics (2002-2004).
PHS 2004-1 Topic 100: Metabonomics of the Liver.
Title: Metabolomics and Pathway Analysis: Urine, Serum, and Liver.

HHSN281200310004C NIAAA Phase I/Phase II Small Business Innovated Research Award.
NIAAA: Sumner PI. Awarded while employed at Paradigm Genetics (2002-2004).
PHS 2004-1 Topic 025: Identification of Genomics, Proteomic, or Metabolomic Differences Associated with Alcohol-Induced Organ Damage and Other Alcohol-Related Diseases.
Title: Metabolomics: Alcohol Induced Toxicity.

Sumner (co-investigator) $70K gift from SNF (2002) for the *Study of the DNA adducts of acrylamide.* Fennell, PI.

Sumner (co-investigator) $200K grant over 1 year (2002) from the Ethylene Propylene Work Group of CMA for the *Study of the effects of ethylene on cytochrome P450 in the rat liver*. Fennell, PI.

Sumner (PI) $100K (2001). *Received gift from SNF for the study of acrylamide*.

Sumner (PI) $280K grant (2000) from TEGEWA for the *Study of acrylamide metabolism in rats following inhalation exposure.*

Sumner (PI) $66K grant (1999) from the Acrylamide Monomer Producers Association for the *Study of acrylamide metabolism following dermal exposure*.

Sumner (PI) $280K grant (1998-1999) from the Styrene Information Research Center for the *Study of the metabolism of Styrene in Exposed Human Volunteers.*

Sumner (PI) $160K grant (1998) from Vulcan Chemicals for *Determining the metabolism of hexachloropropane in rats.*

Sumner (PI) $80K grant (1997-1998) from the Chemical Manufacturers Association for determining *The blood pharmacokinetics of propylene glycol methyl ether and its acetate in rats*.

Sumner (co-investigator) $280K grant over 3 years (1996-1998) from the Alkylphenols & Ethoxylates Research Council for the *Study of the metabolism and disposition of nonylphenol in rats*. Fennell, PI

Sumner (PI) $443K grant (1995-1996) from the American Petroleum Institute for *Determining the metabolism of tertiary amyl methyl ether in rats and mice following multiple routes of exposure*.

Sumner (PI) $469K grant (1995-1996) from the Styrene Information Research Center for *Determination of the metabolism of styrene in rodents.*

Sumner (co-investigator) $250K grant over 5 years (1994-1999) from the Ethylene Oxide Industry Council, EOIC, CMA to *Study the metabolism, pharmacokinetics, and adducts of ethylene oxide*. Fennell, PI.

Sumner (co-investigator) $200K grant over 4 years (1991-1993) from the Ethylene Oxide Industry Council, EOIC, CMA to *Study the carcinogenesis of ethylene oxide.* Fennell, PI.

PROFESSIONAL SERVICE

Editorial Boards

Associate Editor: Environmental Health Perspectives, 2016 to date.

RTI Press, 2010 to 2014.

Editorial Board Member, Journal of Toxicology, 2008 to date.

Board Member, Journal of Applied Toxicology, 2007 to date.

Editorial Board Member, Metabolomics: Official Journal of the Metabolomic Society, 2005 to date.

Selected Positions

Off-site faculty, Wake Forest Translational Sciences Center, 2008 to 2010.

Chair, Project SEED, 2003. Project SEED is a program (under the ACS) aimed at providing support to economically disadvantaged high school students in pursuit of scientific careers.

Previous adjunct or off-site faculty appointments at Duke University (Chemistry), NCSU (Chemistry), and UNC-CH (Environmental Sciences and Engineering).

Selected Chair Positions and Panels

Review Panel Member: National Cancer Institute. ZCA-1-GRB-P-A1. July 21, 2016

Review Panel Member: National Institute of Diabetes and Diabetic Kidney Disease. ZDK1-GRB-N-M1. February 5, 2016.

Session Chair. mQTL: Metabolism and Genetics. International Metabolomics Society Meeting, San Francisco, July 1, 2015

Review Panel Member: National Institute of Mental Health. ZMH1-ERB-M-02. March 11, 2015.

Review Panel Member: National Institute of Diabetes and Diabetic Kidney Disease. ZDK1-GRB-N-M1. February 13, 2015.

Invited Expert. NIEHS Exposome Workshop, NIEHS, RTP, NC, January 14 and 15, 2015.

Review Panel Member: Center for Scientific Review. ZRG1-BCMB-A-51. March 18, 2014.

Review Panel Member: National Institute of Mental Health. ZMHI-ERB-M-04. March 11, 2014

Review Panel Member: National Cancer Institute. ZCA-1-SRLB-3-C1. March 3, 2014.

Review Panel Member, NIEHS Microbiome Review Meeting, July to August 2013.

Review Panel Member: NIDDK, Bridging Adult and Pediatric Therapeutics, June 19, 2012.

Review Panel Member: NIDDK, Metabolomics Technology Development for Large-Scale Studies, May 16, 2012.

Session Chair, Personalized Medicine and Environmental Omics, Environmental Omics Conference, Guangzhou, Guangdong Province, China, November 8 to 12, 2011.

Review Panel Member: NIEHS Superfund Basic Research Program (P42), October 11 and 12, 2011.

Review Panel Member: Bisphenol A Special Study Section, NIEHS, RTP, NC, May 10, 2011.

National Center for Complementary and Alternative Medicine (NCCAM), RTP, NC, March 31, 2011.

Review Panel Member: P30 Environmental Health Centers, NIEHS, RTP, NC, August 10–12, 2010.

Panelist, Personalized Medicine Symposium, sponsored by RTI and the NCBC, the Sheraton Imperial Hotel and Convention Center, RTP, NC, June 15, 2010.

Review Panel Member: Early Detection Research Network (EDRN) Biomarker Development, May 10–11, 2010.

Symposium Chair, Incorporating 'Omics in the Study of Reproduction and Development, SOT 48th Annual Meeting & ToxExpo, March 2009.

Symposium Chair, SOT, Incorporation of 'Omics in the Study of Reproduction and Development, Baltimore, MD, March 2009.

Biomarkers in Studies of Development and Reproduction/Birth Defects, Centers for Disease Control and Prevention, Atlanta, GA, February 2009.

Session Chair, SOT, Safety Assessment Pharmaceutical—Liver, Kidney, Immune System, SOT Annual Meeting and ToxExpo, Seattle, WA, March 2008.

Review Panel Member, NCCAM of NIH. RTP, NC. Review of proposals on omics in alternative medicine. Invited Reviewer. December 2007, 2008, and 2009.

Review Panel Member, NIEHS P50 Environmental Health Centers, RTP, NC, July 2007; Invited Reviewer, July 2007.

Review Panel Member, NIH Special Emphasis Panel, Environmental Health Centers, May 2007; Invited Reviewer, May 2007.

Review Panel Member: NIH Special Emphasis Panel on Metabolomics, Watergate Hotel, Washington, DC, February 2007.

Expert Panel Member: Appointed to the NIH Metabolomics Review Panel, December 2006.

Invited Session Chair and Participant, NIH Roadmap Planning Meeting for Preclinical Safety, August 2006.

Session Chair, NIH Roadmap Workshop on Emerging Preclinical Tools, sponsored by NIGMS, NIH, Lister Hill Auditorium, Bethesda, MD, August 2006.

Invited Participant, Development of a Conceptual Framework for an American Gene Environment Study (AGES), led by Francis Collins (Director of National Human Genome Research Institute), December 2004.

Expert Panel Member, NIEHS Development of the Chemical Effects in Biological Systems (CEBS) Object Model Knowledgebase, 2004 to 2005, January 2004.

Chair and Speaker, Opening the 44th Annual Meeting of the American Society of Pharmacognosy (ASP) with a Symposium on Metabolic Profiling (Metabonomics), Chapel Hill, NC, July 12–16, 2003.

Chair and Panel Discussion Leader—Metabolomics, National ASP Meeting, Metabo(n,l)omics Session, July 2003.

Session Chair, Metabolic Profiling: Pathways in Discovery Conference, Applications for Drug Development, Sheraton Imperial Hotel and Convention Center, RTP, NC, 2002.

Panelist, Round Table Discussions on Metabonomics, NIEHS, RTP, NC, October 25, 2001.

Panelist, Biomedical Engineering Society (BMES) Student Tutorial on Genomics, Proteomics, and Bioinformatics, NCBC, RTP, NC, October 4, 2001.

Chair Discussion Section, P450 Knockout Mice, SOT, March 1999.

Chair, NCACS NMR Discussion Group Poster Sessions, RTP, NC, April 1990–1994, 1996, and 1997.

Chair Platform Session, Metabolism of Drugs and Chemicals, SOT, 1995.

Co-Chair, American Chemical Society Regional Meeting Poster Session, McKimmon Center, NCSU, Raleigh, NC, 1993.

Co-Chair, Molecular Dosimetry Carcinogenesis Poster Discussion Session, American Association Cancer Research, May 1992.

CAREER FOCUS STATEMENT

I have used my training in spectroscopy and physical chemistry to develop and apply tools to elucidate xenobiotic metabolism, and to reveal the impact of exposure (diet, chemical, drug, stress), disease, or dysfunction on biochemical pathways. I have over 25 years of experience in developing and applying nuclear magnetic resonance (NMR), and gas– (GC) and liquid-chromatography (LC)–coupled mass spectrometry (MS) methods in a wide range of environmental, disease, and therapeutic areas.

A large component of my research is conducted in collaboration with clinicians, epidemiologists, toxicologists, and molecular- and micro-biologists to reveal biomarkers, gain mechanistic insights, and derive hypotheses for the development of intervention strategies. My expertise in metabolism and metabolomics, and broad applications in studies of diet, smoking, cancer, diabetes, obesity, cognitive development, liver disease, natural products, maternal and child health, and the environmental influence of disease complements the nutrigenomics research at the UNC Nutrition Research Institute (UNCNRI). Metabolomics provides a means to determine the link between genes and nutrition requirements, and to understand how nutrition impacts gene function.

In addition to contributing metabolomics expertise to UNCNRI projects being led by other investigators, I am interested in bringing new projects to UNCNRI for expanded collaborations. Examples are included in the areas of pregnancy complications, early-life chemical exposure and health outcomes, maternal and child health, diabetes and kidney disease, and human variation in metabolism.

Health Disparities in Pregnancy Complications: In collaboration with Dr. Michelle Williams (Harvard University), metabolomics was used to demonstrate a unique metabolic phenotype in the 2nd trimester serum of women who had a third trimester placental abruption (PA), compared with women who did not have abruption (Gelaye et al., 2016). The probability of PA was increased with an increase in acylcarnitines and a decrease in phosphatidylcholine. Our data, together with evidence that a) prostaglandin-endoperoxide synthase-2 (PTGS-2) is a factor in pre-term delivery (Vaswani et al., 2015), b) low dose aspirin (which inactivates PTGS2) reduces complications in high risk pregnancies, c) the frequencies of SNPs, known to increase dependence on dietary choline, are significantly reduced in low-choline settings (Silver et al., 2015), and d) a breath of research that shows choline plays a critical role in pregnancy, has led us to hypothesize that increased choline (or phosphatidylcholine) preconception or during pregnancy may reduce the incident of PA and other pregnancy complications. I plan to continue to this collaboration, and include others at the UNCNRI, to validate these original findings, to include genomics endpoints, and to aim towards a choline supplementation clinical trial for pregnancy in diverse demographic populations from historically high and low choline settings.

The Impact of Chemical Exposure in utero and Early-in-Life: One of my early studies using metabolomics involved the analysis of biological fluids and tissues of offspring born to pregnant dams exposed to vehicle, low, or high doses of butyl benzyl phthalate (Sumner et al., 2009; Banerjee et al., 2012). This study demonstrated the promise of using metabolomics to reveal the impact of *in utero* exposure on the biochemical profiles of offspring later in life. As a follow-up to these studies, we have more recently demonstrated that nanoparticles, and flame retardants, impact the biochemical profiles of pregnant and lactating rats (Sumner et al., 2010, 2015; Snyder et al., 2015; Fennell et al., 2016) and neonatal mice (Szabo et al., 2016). A recent NIEHS U01 award will enable us to further our research with neonatal mice exposed to nanoparticles for assessment of biochemical perturbations and cognitive outcomes.

Maternal and Child Health: I have collaborated with a number of clinicians and epidemiologists to apply metabolomics in studies of maternal and child health. This includes a recent collaboration with Dr. Rebecca Fry (UNCCH) to analyze cord blood serum from women with "high or normal" exposure to arsenic to demonstrate a metabotype that implicates pathways involved in disease phenotypes with known association with arsenic exposure (Laine et al., 2016, submitted). With Dr. Frederica Perera (Columbia University), I recently completed a study using an innovative modelling approach to link exposure to birth- and early-childhood cognitive outcomes via the metabotye of cord blood (Sumner et al., 2016 submitted). I plan to continue these collaborations to evaluate pathways and propose nutritional approaches to balance metabolic disruptions. Future studies would include the use of genetic models (e.g., collaborative cross) for testing supplementation interventions, and subsequent human subject supplementation trials with genetic, microbiome, and -omics assessments.

The Gut Microbiome, Diet, and Probiotics. Studies with Dr. Martin Blaser (New York University Medical Center) used diet induced obesity mouse models, and fecal transplantation into germ free mice, to demonstrate that an antibiotic-mediated gut microbiome perturbation accelerated the development of type 1 diabetes, with confirmation of perturbed pathways via metabolomics (Livanos et al., 2016). We also recently demonstrated that non-human primates fed prudent versus "western" diets had a significant impact on both the serum and ovarian metabolome, indicating that serum biomarkers could be relevant to ovarian quality (Dhungana et al., 2016). Research with Dr. Saggi Subodh (SUNY Downstate Medical Center) provided compelling evidence that probiotic treatment slows down the progression of chronic kidney disease (Subodh et al., 2016, submitted). Both Drs. Blaser and Subodh plan to continue collaborations with me, and work with UNCNRI investigators to expand studies to include genetic models, and to evaluate genomics profiles in human subject investigations to gain insights into health disparities of diabetes and kidney disease. Lastly, I am a co-investigator in the National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) Glomerular Nephritis Consortium (CureGN), and have an active collaboration with William Smoyer (Nationwide Children/s Hospital) involving understanding steroid resistance in children with nephrotic syndrome. Dr. Jessica Gooding (who I mentor as a NIH K-awardee) will continue working with me, Dr. Smoyer, and Dr. Subodh to complete her k-award focused on GN.

Genetic influences on the variation in biochemistry: More recently, my research program has included evaluating the metabolic profiles of healthy individuals with different blood types to understand more about heritability and how genetics influences the variation in biochemistry- as reflected by the metabotype. I recently published a review of the associations between blood type and disease (Ewald and Sumner 2016), and have a manuscript in development which includes original data demonstrating that metabotypes can be associated with blood types. A second review article, entitled "Blood Type, Microbiome, and Disease," is near submission, which suggests links between blood groups, microbial populations and disease risks. The overall aim of this highly innovative research program will include determining how the heritability of blood type impacts the variation in the metabotype, microbiome, and expression of genes, and how those correlate with, or are perturbed by, exposure (e.g., diet, disease, treatments, chemicals). The metabotype of blood type should help to provide a means to reveal links between genes, gene function, and identify nutritional elements to reduce disease risks.

NIH Core Leadership: I currently serve as the Administrative Core Leader and the Principal Investigator (PI) of the National Institutes of Health (NIH) Common Fund Eastern Regional Metabolomics Research Center (NIH C-F ERCMRC), and as the PI of the National Institute of Environmental Health Sciences (NIEHS)–funded Untargeted Analysis Resource Core (UARC) in the Children's Health Exposure Analysis Resource (CHEAR) Program. The NIH C-F ERCMRC serves as one of six centers in the United States that is working in an NIH Common Fund U24 Consortium to establish standards for targeted and untargeted analysis, increasing clinical and translational research using biomarkers, and providing training. I have also directed an analytical core for the National Center

for Advancing Translational Sciences (NCATS)–funded North Carolina Translational Sciences Institute (NCTRACS) at the University of North Carolina at Chapel Hill (UNC-CH), and the Metabolomics Core for the NIEHS–funded Center for Human Health and Environment at North Carolina State University (NCSU). I will continue to lead the NIH C-F ERCMRC and the CHEAR UARC and contribute as needed to the NCTRACS and CHHE Cores. This Core Leadership experience provides me with many opportunities to develop new methods, and initiate collaborations of most interest to NRI.

Recent Awards: I recently received several sub-awards from collaborative grants that utilize the metabolomics methods developed under the NIH C-F ERCMRC, and comprise a component of my research activities over the next several years. This includes projects with a) Dr. Richard Loeser (UNC-CH) to investigate the metabotype of progressors and non-progressors to knee arthritis, b) Dr. Leo Trasnade (NYUMC) to determine exposure and response biomarkers associated with adolescent diabetes, obesity, and kidney disease, and with c) Dr. Margaret Karagas (Dartmouth College) to reveal biomarkers and mechanisms associated with children's asthma and lung disease.

Training: As part of the NIH C-F ERCMRC and under two NIH C-Fund education awards, I contribute to developing web-based and hands-on training tools to provide researchers and clinicians with basic information to use analytical methods for biomarker discovery. The NIH C-F ERCMRC that I direct has an active intern and visiting scholar program and includes hands-on training. I am committed to continuing this training program, and in particularly, to increase and expand the use of metabolomics in nutrition research at UNC. I am also currently the mentor to one K-awardee (Dr. Jessica Gooding), one NIDA Invest Fellow (Dr. Reza Ghanbari), one post-doctoral fellow (Dr. Yuanyan Li), and several early to mid career staff members who will continue to work on projects funded by the NIH C-F ERCMRC.

Service: I will continue to serve on the Editorial Boards for *Metabolomics*, the *Journal of Applied Toxicology*, the *Journal of Toxicology*, and *Environmental Health Sciences*, and I just started a second term on the Board of Directors for the Metabolomics Society. I also regularly serve on NIH study sections that cover a wide range of topics and disciplines.

SELECTED PAPERS

Novel Approach to the Characterization of Xenobiotic Metabolism and Application in Cross Species Extrapolation for Assessment of Risk.

- Fennell, T.R., Kedderis, G.K., and **Sumner, S.C.J**. (1991). Urinary metabolites of [1,2,3-^{13}C]acrylonitrile in rats and mice detected by ^{13}C nuclear magnetic resonance spectroscopy. *Chemical Research in Toxicology 4*(6):678–687.
- **Sumner, S.C.J**, Fennell, T.R., Moore, T.A., Chanas, B., Gonzalez, F., and Ghanayem, B.I. (1999). The role of cytochrome P450 in the metabolism of acrylamide and acrylonitrile in mice. *Chemical Research in Toxicology 12*(11):1110–1116.
- Fennell, T.R., **Sumner, S.C**, Snyder, R.W., Burgess, J., Spicer, R., Bridson, W.E., and Friedman, M.A. (2005). Metabolism and hemoglobin adduct formation of acrylamide in humans. *Toxicological Sciences 85*(1):447–459.

My early career research at CIIT focused on developing analytical approaches to determine urine and blood based biomarkers of exposure, internal dose, and biologically effective dose. My colleague, Dr. Timothy Fennell, and I develop a new approach to characterize xenobiotic metabolites in urine, to elucidate xenobiotic metabolism, and to readily quantitate metabolites for cross-species comparisons. While researchers had previously incorporated ^{13}C-labels in investigations of metabolism, our research was a first to combine multiple adjacent ^{13}C-labels and 2D-NMR approaches to characterize xenobiotic

metabolites directly in biospecimens - without isolation from the complex mixture (Fennell et al., 1991). Investigations were conducted and published for acrylonitrile, acrylamide (AM), ethylene oxide, butadiene, tertiary amyl alcohol, propargyl alcohol, methoxyethanol, methyl tertiary butyl ether, and styrene. These studies provided information needed to construct physiologically based pharmacokinetic/pharmacodynamic (PBPK/PD) models for assessment of human health risk from exposure. Because this new methodological approach used carbon-13 labeled xenobiotics and did not rely on a priori knowledge of metabolite structure, it was ideal for comparison across species, including comparison of metabolism between rodents and humans. A significant publication was the application of this method to assess the metabolism of AM and acrylonitrile in mice genetically modified to be devoid of cytochrome P4502E1, showing that in the absence of P4502E1, neither the putative toxic epoxide metabolites nor the parent compounds were not detected (Sumner et al, 1999, Chem Res Toxicol, if=5.410, 192 citations). Our studies were extended to investigations to include exposure of human volunteers to carbon-13 labeled compounds (Fennell et al 2005) to provide data for comparison of metabolism between rodents and humans for understanding health risks. The central theme of my work while at CIIT involved incorporation of results in a manner to assess human health risks from exposure to chemicals, thus most if not all of these investigations provided data that was subsequently used to construct PBPK/PD models, and provided significant data and contributions toward EPA Integrated Risk Information System (IRIS) evaluation of acrylamide (IRIS, http://www.epa.gov/iris/subst/0286.htm).

Early Serum Biomarkers of Placental Abruption

- Gelaye B, **Sumner S**, McRitchie S, Carlson JE, Ananth CV, Enquobahrie DA, Chunfang Q, Sorensen TK, Williams MA (2016). Maternal Early Pregnancy Serum Metabolomics Profile and Abnormal Vaginal Bleeding as Predictors of Placental Abruption: A Prospective Study. *PlosOne 11(6):e0156755. doi:10.1371/journal.pone.0156755. PMID: 27300725.*

In 2013, Dr. Michelle Williams (Harvard University) and I began a collaboration aimed at revealing early markers of placental abruption (PA), and also a collaboration to mentor a early career researcher in the Harvard School of Public Health - Dr. Bizu Galye. Placental abruption is an ischemic placental disorder that is documented in 1% of pregnancies, and has known significant adverse health outcomes to the mother and child. Our study aimed to reveal 2nd trimester serum biomarkers that are predictive of 3rd trimester PA. Metabolic profiles of serum were acquired using electrospray ionization liquid chromatography-mass spectrometry and the Biocrates p180 kit. Stepwise logistic regression models and receiver operating characteristics curve analysis were used to determine metabolites predictive of PA. Early pregnancy vaginal bleeding, dodecanoylcarnitine/dodecenoylcarnitine (C12 / C12:1), and phosphatidylcholine acyl-alkyl C 38:1 (PC ae C38:1) strongly predict abruption risk. The AUC for these metabolites alone was 0.68, for early pregnancy vaginal bleeding alone was 0.65, and combined the AUC improved to 0.75 with the addition of quantitative metabolite data (P = 0.003).

Drug-Induced Liver Injury

- **Sumner, S. C**., Burgess, J., Snyder, R., Popp, J., & Fennell, T. R. (2010). Metabolomics of urine for the assessment of microvesicular lipid accumulation in the liver following isoniazid exposure. *Metabolomics*, *6*(2), 238–249.
- Church, R. J., Wu, H., Mosedale, M., **Sumner, S. J.**, Pathmasiri, W., Kurtz, C. L., et al. (2014). A systems biology approach utilizing a mouse diversity panel identifies genetic differences influencing isoniazid-induced microvesicular steatosis. *Toxicological Sciences, 140*(2), 481–492. (Awarded Best Paper of the Year).

In 2005, I received a NIH Roadmap Grant to use metabolomics to investigate drug-induced liver injury, DILI. One of the drugs used in this early study was isoniazid, a drug formulated in the combination cocktail used in the treatment of TB. While isoniazid is efficacious against TB, in some subjects, it adversely impacts the liver, and is one of the leading prescribed drugs within the US that is known to have a causal relationship to catastrophic liver injury, and liver transplantation. The global impact of isoniazid-induced DILI is enhanced due to the high rates of TB, and because patients with HIV and TB have significantly increased likelihood of an adverse DILI response to isoniazid. Our early work in 2005 was the first to demonstrate endogenous biomarkers in urine that associated with the presence of microvesicular lipid accumulation (MVLA) in the liver, and demonstrated urinary markers as surrogates for biochemical perturbations in the liver. MVLA is a reversible pathology of the liver, and early detection of MVLA can change the course of clinical treatment, reducing the likelihood of catastrophic liver failure.

Based on these early results, investigators from UNC-CH, Hamner Institutes, and Pfizer Global Research and Development worked together to extend this investigation to study the mechanisms underlying inter-individual variability in the response to this drug. This project utilized genetically diverse mice (a mouse diversity panel from the collaborative cross), which share a pool of genetic variation from 8 founder inbred strains. A systems biology approach was taken to investigate transcriptional changes and metabolic responses of mouse strains which were sensitive or insensitive to DILI from isoniazied treatment. Genes involved in mitochondrial dysfunction we identified as being enriched among liver transcripts altered with INH treatment. Metabolomic changes indicated a role for oxidative stress and reduced lipid export as contributing factors to INH-induced steatosis. Genome-wide association revealed inter-individual susceptibility to INH-induced steatosis. This study highlights the value of using a mouse diversity panel and systems biology approach to investigate drug-induced responses across a diverse population.