

XINNING ZHANG

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RESEARCH PROGRAM

Influence of microbial metabolism on biogeochemistry of nutrient and energy transfers important for Earth climate. My group combines natural abundance stable isotopes, DNA, RNA, enzymes, process rate measurements to decipher mechanistic controls on microbial function from enzymatic to global scales in modern environments with implications for past and future environments.

Keywords: Biogeochemistry, Geomicrobiology, Geobiology, Environmental Science, Microbial Ecology, Stable Isotopes

POSITIONS

- Since 2017 **Assistant Professor, Princeton University**, Dept. of Geosciences & High Meadows Environmental Institute
- 2014–2017 Associate Research Scholar, Princeton University, Dept. of Geosciences, Advisor: *F.M. Morel*
- 2011–2014 Postdoctoral Researcher, Princeton University, Dept. of Geosciences, Advisor: *F.M. Morel*
- 2010–2011 Postdoctoral Researcher, California Institute of Technology, Division of Geological and Planetary Sciences, Advisor: *A. Sessions*
- 2004–2010 Graduate Researcher, California Institute of Technology, Environmental Science & Engineering, Advisor: *J. R. Leadbetter*

EDUCATION

- 2010 **Ph.D. in Environmental Microbiology**, Environmental Science & Engineering, California Institute of Technology, Pasadena, CA. Advisor: *J. R. Leadbetter*
Thesis: I. Formate dehydrogenase gene diversity of lignocellulose-feeding insect gut microbial communities, II. Metabolic impacts on the hydrogen isotope content of bacterial lipids.
- 2007 **M.S.**, Environmental Science & Engineering, California Institute of Technology, Pasadena, CA. Advisor: *J. R. Leadbetter*
- 2000–2004 **B.S. summa cum laude**, Biological & Environmental Engineering, Cornell University, Ithaca, NY.

HONORS and AWARDS

- 2019–2022 Simons Foundation Early Career Investigators Award in Marine Microbiology and Evolution. *Physiological diversity and environmental sensitivities of benthic marine nitrogen fixation.*
- 2004–2007 National Science Foundation Graduate Research Fellowship.
- 2004–2005 Benjamin Rosen Graduate Student Fellowship, Caltech.
- 2000–2004 Cornell Presidential Research Scholar, Cornell University.

PUBLICATIONS

Students, postdocs advised by Zhang and group members are in **bold**, ^G grad, ^Ppostdoc, ^Uundergrad.

Author identifiers: ORCID: 0000-0003-2763-1526, SCOPUS: 20437094700, [Google Scholar](#)

** > 50, * 30-50 Google scholar citations. *h*-index (all): 20, *i10*-index (all): 25

MANUSCRIPTS SUBMITTED or IN REVISION

- [37] **Han E.** ^G, Kopf S.H., **Maloney A.** ^P, Ai E., Sigman D.M., **Zhang X.** Nitrogen Stable Isotope Fractionation by Biological Nitrogen Fixation Reveals Cellular Nitrogenase is Diffusion Limited (*submitted, PNAS*)
- [36] **Reji, L.** ^P and **Zhang X.** Microbial Dynamics and Geochemistry Constrain Divergent Responses of Wetland Methane Emissions to Oxygen Variability . (*submitted, ISME Communications*)
- [35] **Luxem K.** ^G, **Nguyen A.** ^U, and **Zhang X.** The role of nitrogenase isoform and carbon metabolism in biological nitrogen fixation and diazotrophic growth across a temperature gradient. (*in review, Applied and Environmental Microbiology*)
- [34] **Darnajoux R.** ^P, **Haynes, S.J.** ^P, et al. **Zhang X.** Global role of vanadium for nitrogen fixation in extra-tropical forests (*in review, Science Advances*)

PUBLISHED, IN PRESS, ACCEPTED

- [33] **Maloney A.** ^P, Kopf S.H., Zhang Z., McFarlin J., Nelson D.B., Masterson A.L., **Zhang X.** (2024) Large enrichments in fatty acid ²H/¹H ratios distinguish respiration from aerobic fermentation in yeast *Saccharomyces cerevisiae*. *Proceedings of the National Academy of Sciences USA*, 121: e2310771121. <https://doi.org/10.1073/pnas.2310771121> (*Press 1 , 2*)
- [32] **Darnajoux R.** ^P, Inomura K., **Zhang X.** (2023) A Diazotrophy-Ammoniotrophy Dual Growth Model for the sulfate reducing bacterium *Desulfovibrio vulgaris* var. Hildenborough. *Computational and Structural Biotechnology Journal*, 21: 3136–3148. <https://doi.org/10.1016/j.csbj.2023.05.007>
- [31] **Reji L.** ^P, **Darnajoux R.** ^P, **Zhang X.** (2023) A genomic view of environmental and life history controls on microbial nitrogen acquisition strategies. *Environmental Microbiology Reports*, in press. <https://doi.org/10.1111/1758-2229.13220>
- [30] **Darnajoux R.** ^P, **Reji L.** ^P, **Zhang X.R.** ^U, **Luxem K.E.** ^G, **Zhang X.** (2022) Ammonium sensitivity of biological nitrogen fixation by anaerobic diazotrophs in cultures and benthic marine sediments. *Journal of Geophysical Research: Biogeosciences*, 127, e2021JG006596. <https://doi.org/10.1029/2021JG006596>
- [29] **Luxem K.E.** ^G, **Nguyen A.J.** ^U, **Zhang X.** (2022) Biohydrogen production relationship to biomass composition, growth, temperature and nitrogenase isoform in the anaerobic photoheterotrophic diazotroph *Rhodospseudomonas palustris*, *International Journal of Hydrogen Energy*, 47: 28399-28409. <https://doi.org/10.1016/j.ijhydene.2022.06.178>
- [28] **Reji L.** ^P, **Zhang X.** (2022) Genome-Resolved Metagenomics Informs the Functional Ecology of Uncultured Acidobacteria in Redox Oscillated Sphagnum Peat. *mSystems*, 7, 5. <https://doi.org/10.1128/msystems.00055-22>
- [27] **Haynes S.J.** ^P, **Darnajoux R.** ^P, **Han E.** ^G, Oleynik S., **Zimble E.** ^U, **Zhang X.** (2022) Quantification of biological nitrogen fixation by Mo-independent complementary nitrogenases in environmental samples with low nitrogen fixation activity. *Scientific Reports*, 22011. <https://doi.org/10.1038/s41598-022-24860-9>
- [26]** Yang, J.Q., **Zhang X.**, Bourg I.C., Stone H.A. (2021) 4D imaging reveals mechanisms of clay-carbon protection and release. *Nature Communications*, 12:622 <https://doi.org/10.1038/s41467-020-20798-6> (*Press*)

- [25] Calabrese, S., Garcia, A., **Wilmoth, J.L.**^P, **Zhang, X.**, Porporato, A. (2021) Critical inundation level for methane emissions from wetlands. *Environmental Research Letters*, 16, 044038. <https://doi.org/10.1088/1748-9326/abedea>
- [24]* **Wilmoth J.L.**^P, Schaefer J.K., Schlesinger D.R., Roth S.W., Hatcher P.G., Shoemaker J.K., **Zhang X.** (2021) The role of oxygen in stimulating methane production by wetlands. *Global Change Biology*, 00:1–17. <https://doi.org/10.1111/gcb.15831>
- [23b] **Luxem K.E.**^G, Kraepiel, A.M.L., Zhang, L., Waldbauer, J.R., **Zhang X.** (2022), Carbon substrate re-orders relative growth of a bacterium using Mo-, V-, or Fe-nitrogenase for nitrogen fixation (*Corrigendum*). *Environmental Microbiology*, 24: 2170-2176. <https://doi.org/10.1111/1462-2920.16001>
- [23] **Luxem K.E.**^G, Kraepiel A.M.L., Zhang, L., Waldbauer J.R., **Zhang X.** (2020) Carbon substrate re-orders relative growth of a bacterium using Mo-, V-, or Fe-nitrogenase for nitrogen fixation. *Environmental Microbiology*, 22:1397–1408. <https://doi.org/10.1111/1462-2920.14955> (Press)
- [22]** Bellenger J.P., **Darnajoux R.**^P, **Zhang X.**, Kraepiel A.M.L. (2020) Biological nitrogen fixation by alternative nitrogenases in terrestrial ecosystems: A review. *Biogeochemistry*, 149:53–73. <https://doi.org/10.1007/s10533-020-00666-7>
- [21]** **Zhang X.**, Ward B.B., Sigman D.M. (2020) The Global Nitrogen Cycle: Critical Enzymes, Organisms, Processes for Nitrogen Budgets and Dynamics. *Chemical Reviews*, 120: 5308–5351. <https://doi.org/10.1021/acs.chemrev.9b00613>
- [20] **Luxem K.E.**^G, Leavitt W.D., **Zhang X.** (2020) Large hydrogen isotope fractionation distinguishes nitrogenase derived methane from other sources. *Applied and Environmental Microbiology*, 86: e00849-20. <https://doi.org/10.1128/AEM.00849-20>
- [19] **Zhang X.**, Baars O., Morel F.M.M. (2019) Genetic, structural, and functional diversity of low- and high-affinity siderophores in strains of nitrogen fixing *Azotobacter chroococcum*, *Metallomics*, 11: 201-212. <https://doi.org/10.1039/c8mt00236c>
- [18] McRose, D.L., **Lee A.**^U, Kopf S.H., Baars O., Kraepiel A.M.L., Sigman D.M., Morel F.M.M., **Zhang X.** (2019) Effect of Iron Limitation on the Isotopic Composition of Cellular and Released Fixed Nitrogen in *Azotobacter vinelandii*. *Geochimica et Cosmochimica Acta*, 244:12-23. <https://doi.org/10.1016/j.gca.2018.09.023>
- [17]** **Darnajoux R.**^P, Magain N., Renaudin M., Miadlikowska J., Lutzoni F., Bellenger J.P., **Zhang X.** (2019) Molybdenum threshold for ecosystem scale alternative vanadium nitrogenase activity in boreal forests. *Proceedings of the National Academy of Sciences USA*, 116 (49): 24682-24688. <https://doi.org/10.1073/pnas.1913314116> (Press)
- [16] Baars O., Morel F.M.M., **Zhang X.** (2018) The purple non-sulfur bacterium *Rhodospseudomonas palustris* produces novel petrobactin-like siderophores under aerobic and anaerobic conditions. *Environmental Microbiology*, 20:1667-1676. <https://doi.org/10.1111/1462-2920.14078>
- [15]* Baars O., **Zhang X.**, Gibson M.I., Stone A.T., Morel F.M.M., Seyedsayamdost M.R. (2018) Crochelins, siderophores with a novel iron-chelating moiety from the nitrogen-fixing bacterium *Azotobacter chroococcum*, *Angewandte Chemie*. 57(2):536-541. <https://onlinelibrary.wiley.com/doi/10.1002/anie.201709720>
- [14]** McRose D.L., **Zhang X.**, Kraepiel A.M.L., Morel F.M.M. (2017) Diversity and activity of alternative nitrogenases in sequenced genomes and coastal environments. *Frontiers in Microbiology: Aquatic Microbiology*, 8:267. <https://doi.org/10.3389/fmicb.2017.00267>
- [13]** Darnajoux R., **Zhang X.**, McRose D.L., Miadlikowska J., Lutzoni F., Kraepiel A.M.L., Bellenger J.P. (2017) Biological nitrogen fixation by alternative nitrogenases in boreal cyanolichens: importance of molybdenum availability and implications for current biological nitrogen fixation estimates. *New Phytologist*, 213:680-689 <https://doi.org/10.1111/nph.14166>
- [12]** **Zhang X.**, McRose D., Darnajoux R., Bellenger J.P., Morel F.M.M., Kraepiel A.M.L. (2016) Alternative nitrogenase activity in the environment and nitrogen cycle implications.

- Biogeochemistry*, 127:189-198. <https://doi.org/10.1007/s10533-016-0188-6>
- [11]** Baars O, **Zhang X.**, Morel F.M.M., Seyedsayamdost M.R. (2016) The siderophore metabolome of *Azotobacter vinelandii*. *Applied and Environmental Microbiology*, 82(1): 27-39. <https://doi/10.1128/aem.03160-15>
- [10]** **Zhang X.**, Sigman, D.M., Morel F.M.M., and Kraepiel A.M.L. (2014) Nitrogen isotope fractionation by alternative nitrogenases and past ocean anoxia. *Proceedings of the National Academy of Sciences USA*, 111(13):4782-4787. <https://www.pnas.org/doi/full/10.1073/pnas.1402976111>
- [9]** Bellenger J.P., Xu Y., **Zhang X.**, Morel F.M.M., Kraepiel A.M.L. (2014) Possible contribution of alternative nitrogenases to nitrogen fixation by asymbiotic N₂-fixing bacteria in soils. *Soil Biology and Biochemistry*, 69(0):413-420. <https://doi.org/10.1016/j.soilbio.2013.11.015>
- [8]* Rosenthal A.Z., **Zhang X.**, et al. (2013) Localizing transcripts to single cells suggests an important role of uncultured deltaproteobacteria in the termite gut hydrogen economy. *Proceedings of the National Academy of Sciences USA*, 110 (40): 16163-16168 <https://doi.org/10.1073/pnas.1307876110> *equal contributors
- [7] Matson E.G., Rosenthal A.Z., **Zhang X.**, Leadbetter J.R. (2013) Genome-wide effects of selenium and translational uncoupling on transcription in the termite gut symbiont *Treponema primitia*. *mBio*, 4(6). <https://doi.org/10.1128/mBio.00869-13>
- [6] **Zhang X.**, Leadbetter J.R. (2012) Evidence for cascades of perturbation and adaptation in the metabolic genes of higher termite gut symbionts. *mBIO*, 3(4): e00223-12 <https://doi.org/10.1128/mBio.00223-12>
- [5] **Zhang X.**, Matson E.G., Leadbetter J.R. (2011) Genes for selenium dependent and independent formate dehydrogenase in the gut microbial communities of 3 lower, wood-feeding termites and a wood-feeding roach. *Environmental Microbiology* 13(2): 307-323. <https://doi.org/10.1111/j.1462-2920.2010.02330.x>
- [4]* Matson E.G., **Zhang X.**, Leadbetter J.R. (2010) Selenium controls transcription of paralogous formate dehydrogenase genes in the termite gut acetogen, *Treponema primitia*. *Environmental Microbiology* 12: 2245-2258. <https://doi.org/10.1111/j.1462-2920.2010.02188.x>
- [3]** **Zhang X.**, Gillespie A.L., Sessions A.L. (2009) Large D/H variations in bacterial lipids reflect central metabolic pathways. *Proceedings of the National Academy of Sciences USA*, 106:12580-12586. (PNAS Feature article, Journal Cover, [Commentary](#)) <https://doi.org/10.1073/pnas.0903030106>
- [2]** Warnecke F., Luginbühl P., Ivanova N., Ghassemian M., ..., **Zhang X.**, et al. (2007) Metagenomic and functional analysis of hindgut microbiota of a wood-feeding higher termite. *Nature*, 450: 560-565. <https://doi.org/10.1038/nature06269>
- [1]* Vadas T.M., **Zhang X.**, Curran A.M., and Ahner B.A. (2007) Fate of DTPA, EDTA and EDDS in hydroponic media and effects on plant mineral nutrition. *Journal of Plant Nutrition*, 30:1229-1246. <https://doi.org/10.1080/01904160701555119>

INVITED PRESENTATIONS

- [26] **Reji L.^P** (in place of **Zhang X.**) 'Microbial Hydrogen Cycling across Hydrological Gradients', Gordon Research Conference in Geobiology: Microbes and Global Change Session. Galveston TX, January 2024.
- [-] **Zhang X. (keynote)**, Princeton Center for Theoretical Sciences, PCTS-Space: The Final Frontier of Microbial Communities Workshop, Princeton, NJ, Jan. 2023. *Declined, medical constraints.*
- [-] **Zhang X. (keynote)**, Goldschmidt Conference- Microbial carbon cycling from the continents to the oceans: molecular mechanisms to global impacts on the biosphere (session 10fO1), Lyon, France, August 2023. *Declined, medical constraints.*
- [-] **Zhang X. (keynote)**, *European Geosciences Union-Oxygen and hydrogen isotope analyses of*

- aquatic and terrestrial compounds: Advances in methods, models, and interpretation*, Vienna, Austria, Spring 2023. *Declined, medical constraints.*
- [-] **Zhang. X. (keynote)** Society of Fellows Visiting Scholar Public, Dept. of Earth Science, Dartmouth, 2022. *Declined, medical constraints.*
- [25] **Zhang. X.** et al. Biogeochemistry of methane in wetlands & below ground measurements. *Tropical Wetlands Workshop*, bP and bSR, Princeton, NJ, June 2021.
- [24] **Zhang. X.** et al. Understanding the Biogeochemical Controls of Wetland Methane Emissions. *Carbon Mitigation Initiative, Annual Meeting*, April 2020.
- [23] **Zhang. X.** et al. Why fix? Physiological diversity and Environmental Sensitivities of Benthic N₂ fixation. *1st Annual Meeting Early Career Investigators in Marine Microbial Ecology, Evolution & Fellows in Marine Microbial Ecology*, Simons Foundation Annual Meeting, NYC, NY, Oct. 2019.
- [22] **Zhang. X.** et al. The Wetland Methane Paradox: How does O₂ enhance methane production? Earth and Planetary Sciences Department, Harvard University, Cambridge, MA, May 2019.
- [21] **Zhang. X.** et al. The Wetland Methane Paradox: How does O₂ enhance methane production? Earth and Planetary Sciences Department, Caltech, Pasadena, CA, May 2019.
- [20] **Zhang. X.** et al. The CMI Methane Project: Understanding the Biogeochemical Controls, Sources, and Sinks of Methane. *Carbon Mitigation Initiative, Annual Meeting*, Princeton University, April 2019
- [19] **Zhang. X.** et al. Biogeochemical controls on wetland methane emissions, *CEREAL seminar series*, Princeton University, March 2019.
- [18] **Zhang. X.** et al. Activities & roles of alternative nitrogenases in biological nitrogen fixation, *Department seminar series*, Earth Sciences Department, University of Southern California, CA, Nov. 2017
- [17] **Zhang. X.** et al. Towards a holistic understanding of metalloenzyme biodiversity in biological nitrogen fixation, *Wolman Seminar Series*, Dept. of Environmental Health and Engineering, Johns Hopkins University, MD, Nov. 2017
- [16] **Zhang. X., (keynote)** A multi-windowed view of nitrogen fixation in the lab and field. *Goldschmidt Conference-Tracing Biogeochemical Cycles From Enzyme To Ecosystem* (session 15f), Paris, France, 2017
- [15] **Zhang. X.** et al. Isotopic insights on nitrogen fixation in the lab and field, *Modern Microbes: Portals to Ancient Worlds session*, Geobiology Society Conference, Banff, Canada, June 2017
- [14] **Zhang. X.** et al. Distribution and roles of 'alternative' nitrogen fixation. *Dept. of Energy, Breakthrough Science and Technologies workshop*, EMSL – PNNL, Richland, WA, Jan. 2017
- [13] **Zhang. X.** et al. N₂ fixation by alternative metalloenzymes in the past and present, Dept. Seminar, School of Oceanography, University of Washington – Seattle, WA, Dec. 2016
- [12] **Zhang. X.** et al. N₂ fixation by alternative metalloenzymes in the past and present, Dept. Seminar, Department of Environmental Sciences, Rutgers University, NJ, Mar. 2016
- [11] **Zhang. X.** et al. N₂ fixation by alternative metalloenzymes in the past and present, Dept. Seminar, Biogeochemistry, Environmental Sciences & Sustainability Seminar, Cornell University, NY, Mar. 2016
- [10] **Zhang. X.** et al. N₂ fixation by alternative metalloenzymes in the past and present, Dept. Seminar, Geosciences Dept., Princeton University, NJ, Feb. 2016
- [9] **Zhang. X.** et al. Isotopic biomarkers of nitrogenase metalloenzymes: Forging links between the cycles of nitrogen and trace metals, *Bio-isotopic Message in a Rock Record Bottle session* (Session 8583) AGU Annual meeting, CA, Dec. 2015

- [8] **Zhang. X.** et al. “Alternative” nitrogen fixation by nitrogenases in the past and present, Dept. Seminar, Dept. of Earth and Environmental Science, University of Pennsylvania, Philadelphia, PA, Dec. 2015
- [7] **Zhang. X.** et al. Implications of N₂ fixation by alternative nitrogenases for budgets and beyond, NOAA-Geophysical Fluid Dynamics Laboratory, Princeton, NJ, Nov. 2015
- [6] **Zhang. X.** et al. The importance of alternative nitrogenases in N₂ fixation in the past and present, Department of Environmental Science, American University, Washington DC, Nov. 2015
- [5] **Zhang. X.** et al. The importance of alternative nitrogenases in N₂ fixation in the past and present, *Microbial Systems Seminar Series*, Parsons Lab, MIT, MA, Nov. 2015
- [4] **Zhang. X.** et al. From metalloenzymes to ecosystems: trace metals in the nitrogen cycle, Civil and Environmental Engineering, Temple University, PA, Oct. 2015
- [3] **Zhang. X.** et al. From metalloenzymes to ecosystems: trace metals in the nitrogen cycle, Civil and Environmental Engineering, Temple University, PA, Oct. 2015
- [2] **Zhang. X.** et al. The importance of alternative nitrogenases in N₂ fixation in the past and present, Environmental Geology and Geochemistry Seminar, Princeton University, NJ, Oct. 2015
- [1] **Zhang. X.** et al. Genetic signals for the dynamic evolution of termite gut bacterial symbionts, Remsen-Bird Lecture, Occidental College, CA, Feb. 2011

SELECTED PRESENTATIONS

* Indicates presentations by group members (**bold**)

2017-2024

Paulot, F., **Zhang, X.**, Porporato, A., Saltzman, E., Petron, G. Constraints on H₂ biogeochemical cycle and its climate impact. DOE Annual Merit Review 2024, Washington D.C. May 2024.

* **Reji, L.**, Bertagni, M., Paulot, F., Porporato, A., **Zhang, X.** Lifting the lid on the microbial black box: towards a mechanistic understanding of the soil microbial hydrogen sink. Hydrogen Global Warming Potential Modeling and Management Meeting, DOE Hydrogen Program, Pittsburgh, PA. 2022.

* **Reji L.^P** (in place of **Zhang, X.**) ‘Microbial Hydrogen Cycling across Hydrological Gradients’, Gordon Research Conference in Geobiology: Microbes and Global Change Session. Galveston TX, January 2024. Jan 2024.

* **Reji L., Zhang X.** Oxygen Variability Elicits Differential Responses in Microbial Carbon Mobilization across Wetlands: Implications for Wetland Resilience Under Hydrological Regime Shifts, Abstract 16992, Talk, Goldschmidt, Lyon France, July 2023.

* **Darnajoux R, Koonin S, Dani S, Haynes S,** Magain N, Uchida Y, Lutzoni F., **Zhang X.** Role of cryptogamic covers in metal-nitrogen biogeochemical coupling at the edge of the critical zone, Abstract 18396, Poster, Goldschmidt, Lyon France, July 2023

Wild B., Lammers L. N., **Zhang X.**, White C., Bourg I. C. In-situ mineral probes of local fluid-mineral interactions in soils, Abstract 11605, Goldschmidt, Honolulu HI, July 2022

* **Han E., Maloney A.,** Ai X., Sigman D. M., Kopf S., **Zhang X.** Mechanistic Insights on Cellular Nitrogen Isotope Fractionation by N₂-reducing Mo-nitrogenase, Abstract 12633, Talk, Goldschmidt, Honolulu HI, July 2022

* **Maloney A.,** Diaz B., Bidle K, **Zhang X.** Viral Infection Alters *Emiliana huxleyi* Lipid Hydrogen Isotope Ratios, Poster 4667, American Geophysical Union Ocean Sciences Meeting. Feb. 2022

* **Darnajoux R., Reji L., Zhang X.R., Luxem K.E., Zhang X.** Ammonium sensitivity of biological nitrogen fixation in anaerobic diazotrophs and coastal salt marsh sediments, Talk 4430- OB19, AGU Ocean Sciences Meeting, Feb. 2022

- * **Haynes, S. Darnajoux R., Han E., Oleynik S., Zhang X.** Methodological and analytical improvement of the $\delta^{15}\text{N}$ Acetylene Reduction Assay for the assessment of complementary biological nitrogen fixation in low activity samples, Talk, European Geosciences Union General meeting, May 2022
- * **Darnajoux R. , Reji L., Zhang X.R., Luxem K.E., Zhang X.** (2022) Ammonium sensitivity of biological nitrogen fixation by anaerobic diazotrophs in cultures and benthic marine sediments. Talk, European Geosciences Union General meeting , May 2022
- * **Reji L. , Zhang X.** Genome-resolved metagenomics informs functional ecology of uncultured Acidobacteria in redox oscillated *Sphagnum* peat. Poster, American Society for Microbiology Annual Meeting, June 2022
- Kopf S. , Asamoto C., **Han E., Zhang X.** (2022) A closer look at the isotopic levers of the nitrogen cycle: kinetic isotope effects in denitrification and nitrogen fixation. Talk 3649861, American Chemical Society Annual Meeting, Aug. 2022
- * **Darnajoux R. et al.** Ecosystem scale evidence for the contribution of vanadium-based nitrogenase to biological nitrogen fixation. Talk, European Geosciences Union General meeting, April 2021
- Yang, J. Q., **Zhang X**, Bourg I, Stone H. 4D imaging reveals mechanisms of clay-carbon protection and release, *Poster B25J-1612*, American Geophysical Union Fall Meeting Dec. 2021
- * **Luxem K.,** Taenzer L., Leavitt W., **Zhang X.** Trends in Mo-, V- and Fe-only-based Biological Nitrogen Fixation across a Temperature Gradient in the Alphaproteobacterium *Rhodopseudomonas palustris*. Poster, American Geophysical Union Fall Meeting, Dec. 2020
- * **Zhang X. et al.** The role of alternative metals in biological nitrogen fixation. Poster, Gordon Research Conference in Geobiology, Galveston TX, Jan. 2020.
- * **Han E.,** Kopf S.H., **Zhang X.** Nitrogenase Structure-Function Constraints on Nitrogen Stable Isotope Fractionation during Biological N_2 Fixation, Poster, Gordon Research Conference in Geobiology, Galveston TX, Jan. 2020.
- * **Darnajoux R., Zhang X. R., Luxem K., Zhang X.** The fixed nitrogen sensitivity of biological nitrogen fixation in salt marshes sediments from the northeastern United States, Talk, European Geosciences Union, <https://doi.org/10.5194/egusphere-egu2020-11857>, April 2020
- * **Zhang. X. et al.** Oxic-Anoxic Transition Stimulates Methane Production by Wetland Peat. Poster. Gordon Research Conference in Applied and Environmental Microbiology. South Hadley, MA. July 2019.
- * **Luxem K.,** Taenzer L., Leavitt W., **Zhang X.** Large hydrogen isotope fractionation distinguishes nitrogenase derived methane from other sources. Poster, Gordon Research Conference in Applied and Environ. Microbiology, South Hadely, MA. July 2019.
- * **Maloney A.,** Kopf S.H., **Zhang X.** Effect of growth rate on the carbon and hydrogen isotopic composition of biomass and lipids in *Saccharomyces cerevisiae*, Poster, Rocky Mountain Geobiology Conference, Boulder CO, April 2019.
- * **Luxem K.,** Kraepiel A.M.L., **Zhang X.** Physiological Implications of Alternative Nitrogen Fixation. Poster, AGU annual meeting, Washington DC, Dec. 2018
- * **Wilmoth J., et al.** Redox Transitions Enhance Methane Production in Peat Systems., Poster, AGU annual meeting, Washington DC, Dec. 2018
- * **Han E., Maloney A.,** Kopf S.H., **Zhang X.** Alteration of the a-70 “gatekeeping” residue of the Mo-nitrogenase active site increases cellular scale nitrogen isotope fractionation during biological nitrogen fixation, Poster, AGU annual meeting, Washington DC, Dec. 2018
- * **Darnajoux R., Zhang X. R., Zhang X.** The Fixed Nitrogen Sensitivity of Biological Nitrogen Fixation in the Sulfate-Reducing Diazotroph, *Desulfovibrio vulgaris*. Poster, AGU annual meeting, Washington DC, Dec. 2018

- * **Luxem K.**, Kraepiel A.M.L., **Chiu C.**, **Zhang X.** Use of alternative V-nitrogenase for redox homeostasis in *Rhodospseudomonas palustris.*, Talk, Goldschmidt, Boston, Aug. 2018
- * **Han E.**, **Maloney A.**, Kopf S.H., **Zhang X.** Active site constraints on nitrogen stable isotope fractionation by Mo- dependent nitrogenase, Poster, Goldschmidt, Boston, Aug. 2018
- * **Darnajoux R.**, et al. Molybdenum availability controls vanadium nitrogenase activity in boreal forest cyanolichens. Poster, 13th European Nitrogen Fixation Conference, Stockholm, Sweden. 2018.
- * **Darnajoux R.** et al. Molybdenum availability controls vanadium nitrogenase activity in boreal forest cyanolichens. Talk, ISME, Leipzig, Germany. 2018.
- * **Wilmoth J.** et al. The methane paradox in peat systems is linked to redox transitions. Talk, Goldschmidt, Boston, Aug. 2018.
- * **Luxem K.**, Chiu C., Kraepiel A.M.L., **Zhang X.** A role for the alternative V-nitrogenase in redox homeostasis. Talk, Northeast Geobiology Symposium, University of Connecticut, USA, 2017.
- * **Darnajoux, R. et al.** A glimpse at the lichen symbiosis; from metal homeostasis to ecosystems function." (Talk, Northeast Geobiology Symposium, University of Connecticut. 2017.
- Zhang. X. et al.** A multi-windowed view of nitrogen fixation in the lab and field. *Goldschmidt Conference-Tracing Biogeochemical Cycles From Enzyme To Ecosystem* (keynote, session 15f), Paris, France, July 2017.
- Zhang. X. et al.** Isotopic insights on nitrogen fixation in the lab and field, *Modern Microbes: Portals to Ancient Worlds session*, Geobiology Society Conference, Banff, Canada, June 2017.

2007-2016

- * **Lee A.**^U, Kopf S., **Zhang X.** Iron availability influences ¹⁵N-isotope fractionation during nitrogen fixation by aerobic chemoheterotroph *Azotobacter vinelandii* (Poster, AGU annual meeting, San Francisco, Dec. 2016.
- Sessions A.L, Wijker R., Osburn M., **Zhang X.**, Niepke T. Hydrogen isotope fractionation in microbial metabolism. Gordon Conference in Geobiology, Galveston, TX. 2016.
- Zhang X.**, et al. Forging links between the cycles of nitrogen and trace metals using stable isotope biomarkers of nitrogenase metalloenzymes, Poster, 19th International Nitrogen Fixation Conference, Asilomar, CA. Dec. 2015
- Zhang X.**, et al. Coupled Biogeochemistry of Nitrogen and Trace Metals: Isotopic Acetylene Reduction Assay (ISARA) Indicates Significant Alternative Nitrogenase Usage in the Environment. Poster, Carbon Mitigation Initiative Annual Meeting, Princeton, NJ. 2015
- Zhang X.**, et al. Coupled Biogeochemistry of Nitrogen and Trace Metals: Isotopic Acetylene Reduction Assay (ISARA) Indicates Significant Alternative Nitrogenase Usage in the Environment. Poster, American Society of Microbiology Annual Meeting, New Orleans, Louisiana, Dec. 2015.
- Zhang X.**, et al. Isotopic Acetylene Reduction Assay (ISARA) Indicates Significant Alternative Nitrogenase Usage in the Environment. Poster, Northeastern Geobiology Conference, Princeton, NJ. 2015.
- Zhang X.** et al. Isotope fractionation by alternative nitrogenases and past ocean anoxia.(oster, American Geophysical Union, San Francisco, CA., Dec. 2013
- Zhang, X.**, Sessions, A.L.', Gillespie, A. L. Huge variations in D/H fractionation associated with microbial heterotrophy. *Poster*, Goldschmidt Conference, University of British Columbia, Vancouver, Canada. 2008. 'presenter
- Zhang X.**, et al. Formate dehydrogenase diversity in the homoacetogenic spirochete *Treponema primitia* and in termite hindgut microbial communities suggests their adaptation to a changing selenium environment. Poster, 2nd Conference on Beneficial Microbes, American Society for Microbiology, San Diego, USA. Oct. 2008.

Zhang X., et al. Formate dehydrogenase diversity in the homoacetogenic spirochete *Treponema primitia* and in termite hindgut microbial communities suggests their adaptation to a changing selenium environment. Poster, Society for General Microbiology, University of Edinburgh, Scotland, Sept. 2007.

Zhang X., et al. Formate dehydrogenase diversity in the homoacetogenic spirochete *Treponema primitia* and in termite hindgut microbial communities. Talk. Annual Meeting of the West Coast Bacterial Physiologists. Asilomar, CA, Dec 2016.

TEACHING

PRINCETON UNIVERSITY

Semester	Course	Title	Students
Sp. 2017	ENV200F	Environmental Nexus (Science & Technology section)	77
Sp. 2018	ENV200F	Environmental Nexus (Science & Technology section)	5
Fall 2018	GEO416 / ENV418	Microbial Life: A Geobiological View	8
Sp. 2019	GEO506	Fundamentals of Geosciences	6 (team taught)
	GEO506	Fundamentals of Geosciences	14 (team taught)
Fall 2019	ENV200F	Environmental Nexus (Science & Technology)	27
Sp. 2020	GEO416 / ENV418 GEO 506	Microbial Life: A Geobiological View Fundamentals of Geosciences	8 5 (team taught)
Fall 2020	ENV200F	Environmental Nexus (Science & Technology)	51
Sp. 2021		Medical leave	
Fall 2021	ENV200F	Environmental Nexus (Science & Technology section)	17
Sp. 2022	GEO416 / ENV418	Microbial Life: A Geobiological View	4
Fall 2022		Course development	
Sp. 2023		Medical leave	
Fall 2023	FRS115	Freshman Seminar: Decomposing the Science of Composting to Turn Waste into Resource	11 (co-taught)
Sp. 2024	GEO 506	Fundamentals of Geosciences	5 (team taught)

OTHER INSTITUTIONS

Fall '06, '07, '08	Upper level undergrad/grad	Microbial Physiology (CALTECH)	Teaching assistant, Lab instructor (~ 10-15 students)
Fall '03	Upper level undergrad	Engineering Thermodynamics (CORNELL)	Teaching assistant (15 students)

ADVISING and MENTORING

GRADUATE STUDENTS (2 as PRIMARY ADVISOR 2, 10 as COMMITTEE MEMBER)

PRIMARY ADVISEES - 2

Katja E. Luxem (2017-2021) Physiology of Biological Nitrogen Fixation by Nitrogenase Enzymes with Molybdenum, Vanadium, or Iron-Only Metal Cofactors (NSF Fellowship and grant, PEI Walbridge Fellowship, PEO Scholars Award)
Currently Research Scientist, Metrohm, Switzerland

Eunah Han (2017-2024) Stable Isotopic Investigations of Enzyme Mechanism, Efficiency, and Environmental Activity of Biological Nitrogen Fixation by Nitrogenase Enzymes (Kwanjeoung Fellowship, HMEI Hack Fellowship, NASA & HMEI PWI grants)

OTHER GRADUATE STUDENT ADVISEES (GEO dept) - 10

Emma Kast (2019– 2020)
John Tracey (2017– 2022)
Julia Carroll (2017– 2019)
Ryan Manzuk (2018-2020)
Naomi Intrator (2017– present)
Zachary Garvin (2017– 2024)
Yeongjun Ryu (2018 – present)
Jenna Lee (2019– present)
Moriah Kunes (2020– present)
Catherine Hexter (2022– present)

POSTDOCTORAL RESEARCHERS - 6

Dr. Romain Darnajoux (2017–2023) Funded by Simons Foundation Life Science Research Fellowship, Simons Foundation Early Career Award (Zhang), Princeton CMI.
Currently: *Marie Curie Fellow, University of Toulouse*

Dr. Jared Wilmoth (2017–2020) Funded by Princeton CMI.
Currently: *Assistant Professor, Dept. Env Sci. & Technology, U. of Maryland*

Dr. Ashley Maloney (2018–2023) Funded by Princeton Dept. of Geosciences Hess Fellowship, Simons Foundation Postdoctoral Research Fellowship in Marine Microbiology.
Currently: *Research Scientist & Facility Manager, CU Boulder Earth Systems Stable Isotope Lab, University of Colorado-Boulder*

Dr. Emma Bertran (2019-2021) Funded by NASA-Exobio grant, Simons Foundation Early Career (Zhang)
Currently: *Scientific Editor for journal Data in Brief, Elsevier*

Dr. Linta Reji (2020–2024) Funded by Simons Foundation Early Career Award (Zhang), Princeton CMI
Upcoming: *Assistant Professor, Geophysical Sciences Department, U. of Chicago*

Dr. Qianhui Qin (2024–present) Funded by DOE-NOAA grant.

PROFESSIONAL SCIENTISTS - 1

Dr. Shannon Haynes (2017–present) Zhang Lab Manager, Research Scientist, Funded by NSF-IODP grant (Haynes), Simons Foundation Early Career Award (Zhang), CMI, DOE-NOAA grant, GEO, HMEI Startup

UNDERGRADUATE STUDENTS– 15 at Princeton

JUNIOR PROJECT (JP-2), SENIOR THESIS (ST-2),
HMEI/PEI SUMMER RESEARCH INTERNS (INT-11)

2022 Jacob Stoebner (ST in GEO, 2nd reader)
Sessina Dani (INT), Spencer Koonin (INT), Emily Yang (INT)

2021 Isabel Rodrigues (JP in GEO, primary advisor),
Nathan Levy (ST in GEO, 2nd reader)

2020 Galen Cadley (JP in GEO, primary advisor)

2019 Calvin Rusley (ST in GEO, primary advisor)

- Mitch Mitchell (ST in GEO, 2nd reader)
Ezra Zimble (INT), Gabrielle D'Arcangelo (INT), Aaron J. Nguyen (INT), Louison Sall (INT)
- 2018 Calvin Rusley (JP in GEO, 2nd reader), SiSi Peng (JP in GEO, 2nd reader),
Henry Ogilby (ST in Geo, 2nd reader)
Xin Rei Zhang (INT)
- 2017 Carol Chiu (ST in CBE, primary advisor)
Kayla Dobies (INT), Kelly Van Baalen (INT),
- 2016 Allison Lee (INT)
- 2015 Carol Chiu (JP in CBE, co-advisor with Prof. F. Morel)
- 2010 Yang Hu (Amgen Scholar, Caltech)

GRANTS

Awards to Zhang's group, *excluding amounts to other co-PIs, are in **bold***.

Total active in 2024 ~\$1.1 M, Total 2017-present ~ \$3.4 M

- 2023-2024 NJ-Department of Environmental Protection "Optimizing Recycling at Princeton University", Award SHW22-007 (AWD1007385), PI: X. Zhang (replacing S. Weber)
Budget: \$67,073 (**None**)
- 2023-2026 Interagency Agreement Between NOAA (Climate Program Office) and the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy for Studies on Atmospheric Hydrogen. (DOE Hydrogen Program)
PI: X. Zhang, Co-PI: A. Porporato, HMEI
Budget: **\$1,000,043**
- 2022–2024 High Meadows Environmental Institute – Water Grand Challenge
Hydrological Controls on Microbial H₂ Uptake: Constraining the Soil Hydrogen Sink Under Changing Soil Moisture Regimes
PI: X. Zhang, Co-PI: L. Reji (postdoc)
Budget: **\$149,850**
- 2021–2024 High Meadows Environmental Institute – Princeton Watershed Initiative Award
Linking Geomorphology, Hydrology, and Soil Science for the Efficient Management of Agriculture Lands and Water Quality of Associated Streams
PI: S. Myneni, Co-PIs: IBourg, X. Zhang, A. Porporato
Budget: \$300,000 (**\$75,000**)
- 2021–2024 High Meadows Environmental Institute – Biodiversity Grand Challenges Award
What controls the Biodiversity and Function of Cryptogam Microbiomes
PI: X. Zhang, Co-PI: R. Darnajoux (postdoc)
Budget: **\$100,000**
- 2019– Princeton Campus as a Lab: Research in Sustainability, Energy, & the Environment: Characterizing Microbial Communities in Aerobic Biodigester Compost to Improve Plant Growth and Limit Greenhouse Gas Emissions
PI: X. Zhang
Budget: **\$12,000**
- 2019–2022 Simons Foundation Marine Microbiology & Evolution Early Career Award
Physiological diversity and environmental sensitivities of benthic marine nitrogen fixation
PI: X. Zhang
Budget: **\$624,000**

- 2017–2020 NASA – Exobiology (grant 80NSSC17K0667)
What controls the nitrogen isotope fractionation of N₂ fixation? (PI)
PI: X. Zhang, Co-PI: S. Kopf (University of Colorado, Boulder)
Budget: **\$512,478**
- 2017–2020 Princeton Environmental Institute – Carbon Mitigation Initiative
Investigations of wetland methane production
PI: X. Zhang
Budget: **\$351,542**
- 2020–2024 High Meadows Environmental Institute - Carbon Mitigation Initiative
Investigations of wetland methane and soil hydrogen cycling
PI: X. Zhang
Budget: **\$1,050,000**
- 2016–2020 National Science Foundation – Geobiology (EAR grant 1631814)
Alternative nitrogenases: How much do they contribute to N₂ fixation and why?
PI: A. Kraepiel, Co-PI: X. Zhang
Total budget: **\$357,768**
- 2015–2017 Princeton Environmental Institute – Grand Challenges Investigator Award
Controls on alternative N₂ fixation: consequences for land sequestration of anthropogenic
CO₂ and biohydrogen production (Co-PI)
PI: A. Kraepiel, Co-PI: X. Zhang
Total budget: **\$150,000**
- 2018–2022 Tuttle Invertebrate Research Fund, Dept. Geosciences, Princeton University
The role of alternative nitrogenases in termites
PI: X. Zhang
Budget: **\$195,00**

OUTREACH and EDUCATIONAL PROGRAMS

- 2023-present Lead PI w/ Gina Talt, Andrew D’Amico, Princeton Office of Sustainability -NJDEP Project
“[Advancing institutional Recycling goals through compostable plastic product and user interface testing](#)”
- 2023 Developed new applied lab research course for freshman on composting (FRS115) to support NJDEP Campus Sustainability Project Goals
- 2019-present Collaborator, Sustainable Composting Research Lab at Princeton
- 2022 Research Proposal Advisor “Effects of bacteria, *B. subtilis*, *R. leguminosarum*, and *S. griseus* on greenhouse gas emissions from compost” (E. Ulbak, Princeton High School)
- 2018 Laboratory host for Watershed Institute’s Summer Climate Change Academ
- 2017 Focus Feature HHMI Interview: “[I Contain Multitudes – Termite gut microbes](#)” with Science Writer, Ed Yong
- 2015-present Princeton Early Career Researchers in Geosciences PWIGS mentor (8 women)
- 2010-2011 Caltech Women Mentoring Women Program mentor

SELECTED PROFESSIONAL ACTIVITIES and SERVICE

- 2023 Co-Organizer, Princeton Center for Theoretical Sciences, [Space: The Final Frontier of Microbial Communities Workshop, Princeton, NJ](#)
- 2021/22 Dept. Geosciences, DEIA lending library, oversight and admin. by Zhang lab
2021. Organizing committee, Tropical Wetlands Workshop sponsored by companies BP, BSR
- 2020 Faculty committee PU COVID parental aid policies
- 2019 PEI (HMEI): Graduate Studies Committee, Walbridge fund proposal review, PEI-STEP fellows proposal review

- 2018 [Chair and Convener, Session B092 Nitrogen Biogeochemistry](#),
American Geophysical Union Annual Fall meeting (Washington DC)
- 2017 Organizer, Environmental Geology & Geochemistry Seminar, Princeton
- 2018-'20 Co-organizer, Department Seminar Series, Geosciences Dept., Princeton University
- 2017- Dept. Geosciences, Environmental Sciences Building Committee
- 2017/'18. Dept. Geosciences, Hess Postdoctoral Fellow Search Committee

Article Reviewer for Scientific Journals including: *Proceedings of the National Academy of Sciences USA*,, *Nature*, *Nature Communications*, *Nature Geoscience*, *Applied and Environmental Microbiology*, *Environmental Microbiology*, *FEMS Microbiology*, *Organic Geochemistry*, *Geochimica et Cosmochimica Acta*, *mBio* (invited editor, 8:e00570-17)

Proposal Reviewer for *National Science Foundation*, *Dept. of Energy (SBR Biogeochemistry panel review 2017)*, *DOE- EMSL Breakthrough Science & Technology Workshop, 2017*, *American Chemical Society*, *Schlumberger*