Primitive Metallo Nucleic Acids. C. Switzer,* E.-K. Kim, B. D. Heuberger, D. Shin, N. Rico, and S. Vaidya, Department of Chemistry, University of California — Riverside, Riverside, CA 92521; *e-mail: Christopher.Switzer@ucr.edu.

Although the prebiotic origins of nucleic acids have been studied for more than half a century, it remains unclear whether nucleotides are more easily derived from serial condensations of integral subcomponents, or "holistic" organic processes [1-5]. Oro's discovery that hydrogen cyanide oligomerizes over the course of days to generate adenine is an early testament to the abiotic accessibility of purine nucleobase constituents [6]. While meteoritic amino acids have been long established [7], unequivocal evidence for extraterrestrial nucleobases is recent [8]. In particular, the detection of terrestrially rare nucleobases in a wide range of carbonaceous meteorites notably expands the inventory of molecules that would have been available on the early Earth and elsewhere during periods of heavy bombardment [8,9]. Within this expanded inventory, a diverse array of nucleobases capable of association by hydrophobic or metal mediated interactions may be anticipated, in addition to those that hydrogen bond.

Extraterrestrial "nucleobases" capable of metal-ion-mediated base pairing have been reported. Pyridine, pyridine-2-carboxylate and pyridine-2,5-dicarboxylate have been recently identified in carbonaceous chondritic meteorites [10]. These pyridine derivatives serve as the foundation for metal-mediated DNA base pairs that have been synthesized in past work and shown to pair in DNA double helices alongside natural base pairs [11,12].

Additional examples of extraterrestrial nucleobases capable of metal-ion-mediated base pairing await identification, in much the same way that additional examples of hydrogen bond forming extraterrestrial nucleobases also await identification. Indeed, purine itself was among the extraterrestrial nucleobases identified by Callahan et al in 2011 [8]. Purine is expected to react with carbon dioxide under astrophysical conditions to yield purine carboxylates, including purine-6-carboxylate and purine-2,6-dicarboxylate in analogy with the known reaction of pyridine with carbon dioxide to give pyridine carboxylates as demonstrated in the laboratory (and as evidently occurs astrophysically given their recent identification in CM chondrites; [10]). The Switzer laboratory has recently synthesized and characterized metal-ion-mediated base pairs that incorporate extraterrestrially relevant purine carboxylates and pyridine, respectively [13,14]. The presentation will explore the prebiotic and early biotic functional fitness of these astrophysically plausible nucleobases capable of metal-ion-mediated base pair formation.

References:

[1] Orgel, L. E. (2004) *Crit. Rev. Biochem. Mol. Biol. 3*9, 99-123. [2] Powner, M. W., Gerland, B. and Sutherland, J. D. (2009) *Nature, 459*, 239-242. [3] Switzer, C. (2009) *ChemBioChem 10*, 2591-2593. [4] Benner, S. A., Kim, H.-J. and Carrigan, M. A. (2012) *Accts. Chem. Res. 45*, 2025-2034. [5] Bean, H. D., Sheng, Y. H., Collins, J. P., Anet, F. A. L., Leszczynski, J., Hud, N. V. (2007) *J. Am. Chem. Soc. 129*, 9556−9557. [6] Oro, J. (1960) *Biochem. Biophys. Res. Commun. 2*, 407-412. [7] Pizzarello, S. and Huang, Y. (2005) *Geochim. Cosmochim. Acta 69*, 599-605. [8] Callahan, M. P., Smith, K. E., Cleaves, J., Ruzicka, J., Stern, J. C., Glavin, D. P., House, C. H., Dworkin, J. P. (2011) *Proc. Natl. Acad. Sci. U. S. A. 108*, 13995-13998. [9] Chyba, C. and Sagan, C. (1992) *Nature 9*, 125-132. [10] Smith K. E., Callahan, M. P., Gerakines, P. A., Dworkin, J. P., House, C. H. (2014) *Geochim Cosmochim Acta, 136*, 1-12. [11] Tanaka, K., Yamada, Y., and Shionoya, M. (2002) *J. Am. Chem. Soc. 124*, 8802-8803. [12] Meggers, E., Holland, P. L., Tolman, W. B., Romesberg, F. E., and Schultz, P. G. (2000) *J. Am. Chem. Soc. 122*, 10714-10715. [13] Kim, E.-K. and Switzer, C. (2013) *ChemBioChem 14*, 2403-2407. [14] Kim, E.-K. and Switzer, C. (2014) *Organic Letters 16*, 4059–4061.